Rehabilitation Processes following Traumatic Brain Injury

Gillian Lorraine Ta'eed

BA Psychology (Hon), Master of Psychology (Clinical)

School of Psychology

University of Tasmania

Submitted in fulfilment of the requirements of the degree of

Doctor of Philosophy in Psychology at

University of Tasmania, July 2012

All blessings are divine in origin, but none can be compared with this power of intellectual investigation and research, which is an eternal gift producing fruits of unending delight.

‘Abdu’l-Bahá, The Promulgation of Universal Peace, p. 50

Declaration of Originality

This thesis contains no material which has been accepted for a degree or diploma by the University or any other institution, except by way of background information and duly acknowledged in the thesis, and to the best of my knowledge and belief no material previously published or written by another person except where due acknowledgement is made in the text of the thesis, nor does the thesis contain any material that infringes copyright.

____

Gillian L. Ta'eed

July 2012

Statement of Ethical Conduct

The research associated with this thesis abides by the international and Australian codes on human and animal experimentation, the guidelines by the Australian Government's Office of the Gene Technology Regulator and the rulings of the Safety, Ethics and Institutional Biosafety Committees of the University.

____

Gillian L. Ta'eed

July 2012

Authority of Access

This thesis may be made available for loan and limited copying and communication, in accordance with the Copyright Act 1968.

Gillian L. Ta'eed

July 2012

Abstract

Traumatic brain injury (TBI) may result in significant impairment in an individual's physical, cognitive and psychosocial functioning, and is acknowledged to be the leading cause of long-term disability in young adults (DSM III; 1999). An increasing body of high-quality evidence now exists for the effectiveness of rehabilitation interventions for TBI of all severities (Powell, Heslin, & Greenwood, 2002; Turner-Stokes, 2008; Wade, Crawford, Wenden, King, & Moss, 1997). However, there is a need for a more comprehensive description of the types of care allocated at the end of the acute phase of TBI, and the factors that influence variation in referral and access to services. Much of the literature focuses on people with severe TBI receiving specialist rehabilitation, and considers only hospitalised cases.

The aims of the present research were to investigate patterns of referral to outpatient rehabilitation services in a population-based sample, to describe factors related to progress in rehabilitation for those referred to public community rehabilitation, and to increase understanding of TBI and its management, by developing a model of rehabilitation pathways. Study 1 looked at some demographic, injury-related, and post-injury characteristics of the participants of the Tasmanian Neurotrauma Register (TNTR) research project (N = 1226), and examined differences in the groups referred to public and private rehabilitation. Studies 2, 3 and 4 looked at the sub-sample of individuals (n = 175) referred for public multidisciplinary rehabilitation at the Community Rehabilitation Unit (CRU). These three studies considered how a range of variables were related to referral to CRU's clinical disciplines, to the likelihood of being offered appointments, and to attendance or non-attendance at initial appointments, when offered them. Study 5 looked further at how

rehabilitation services contribute to TBI patients' recovery by considering the amount and nature of therapy participants received at CRU.

This research provides clinicians and researchers with a clearer picture of some of the factors that affect the post-acute rehabilitation process, in a sample of TBI patients that is more representative of adult TBI than those found in the overwhelming majority of studies, which typically consider only moderate to severe TBI and/or hospitalised cases. The rehabilitation pathways and processes outlined will be valuable for rehabilitation clinicians who wish to identify people at risk of poor outcomes. The findings of this research provide a foundation upon which a number of avenues for further research can be based. These include looking at different measures of outcome in TBI samples referred for community rehabilitation, identifying effective interventions that are compatible with existing rehabilitation services, and comparing outcomes in matched samples referred and not-referred for rehabilitation.

Acknowledgments

Firstly, I would like to thank my supervisor Associate Professor Clive Skilbeck for his endless guidance, support and encouragement over the course of this research.

This project took place as part of the Tasmanian Neurotrauma (TNTR) research project, which was funded by the Motor Accident Insurance Board of Tasmania. I am grateful to the project's chief researcher, Dr. Mark Slatyer for his support, and to the many TNTR staff and participants who helped to collect and collate the project's data. In particular I would like to thank the TNTR's coordinators, Dr. Tracey Dean and Dr. Sama Colquhoun; and especially Dr. Matthew Thomas, who has always been a source of inspiration and advice. In addition, I express my thanks to Dr. John Davidson (School of Psychology, University of Tasmania) for his support and encouragement with some aspects of the analyses.

The research reported in this thesis resulted from collaboration between the Community Rehabilitation Unit (CRU), an agency of the Department of Health and Human Services in Tasmania, and the University of Tasmania. My thanks are due to all the CRU staff—too numerous to mention individually—who helped me with this research, and who were always open and welcoming. In particular I would like to thank Ms Jenny Langley, Dr. Maryanne Davis, Dr Iain Montgomery, and Dr. Peggy Foreman who each assisted me in many ways over the life of the project. I also thank Mr. Paul Shinkfield, who was the manager at CRU when I began the research, for his help negotiating the agreement between the two agencies, and Ms Kerry Williams, the current manager, for her support and willingness to read and comment on some of my early write-ups about CRU's clinical services.

Last, but definitely not least, I express my enduring gratitude to my husband Fuad, without whom I would not have even thought of embarking on this project, and who has given me constant support and encouragement throughout it.

TABLE OF CONTENTS

List of Tables

Chapter 6

List of Figures

List of Appendices

List of Abbreviations

ABI	Acquired brain injury
AMCR	American Congress of Rehabilitation Medicine
AMIPB	Adult Memory and Information Processing Battery
ANOVA	Analysis of Variance
ASCO	Australian Standard Classification of Occupations
COWAT	Controlled Oral Word Association Test
CRU	Community Rehabilitation Unit
CT	Computed tomography
DHHS	Department of Health and Human Services (Tasmania)
DRS	Disability Rating Scale
DSM	Diagnostic and Statistical Manual for Mental Disorders
ED	Emergency Department
FFT	Face-to-face therapy in hours
FIM	Functional Independence Measure
FSIQ	Full scale Intelligence Quotient
FTE	Full-time equivalent
GCS	Glasgow Coma Scale
GOAT	Galveston Orientation and Amnesia Test
GOS	Glasgow Outcome Scale
GP	General Medical Practitioner
HADS	Hospital Anxiety and Depression Scale
HV	Home visit
ICD	International Statistical Classification of Diseases and Related Health Problems

ICF	The International Classification of Functioning, Disability and Health
IQ	Intelligence quotient
LGH	Launceston General Hospital
LOC	Loss of consciousness
MRI	Magnetic resonance imaging
mTBI	Mild traumatic brain injury
NART	National Adult Reading Test
NIH	National Institutes of Health
NWRH	North West Regional Hospital
PCS	Post-concussion symptoms
PTA	Post traumatic amnesia
RCT	Randomised controlled trials
RWPTAS	Revised Westmead Post Traumatic Amnesia Scale
RPQ	Rivermead Post-Concussion Symptoms Questionnaire
RHH	Royal Hobart Hospital
SPSS	Statistical Package for the Social Sciences
TBI	Traumatic brain injury
TNTR	Tasmanian Neurotrauma Register
TT	Total therapy in hours
TTC	Telephone therapy calls in hours
UK	United Kingdom of Great Britain and Northern Ireland
USA	United States of America
WAIS	Wechsler Adult Intelligence Scale
WHO	World Health Organisation

CHAPTER 1 - Introduction and Thesis Overview

Rehabilitation following traumatic brain injury (TBI) has grown significantly over the last fifty years as medical advances have allowed increasing numbers of people with severe injuries to survive. Increased interest in this area is reflected in the growth of publications: A Medline search showed that until 1987 there were fewer than 20 TBI rehabilitation publications listed each year, but since 2000 this number has grown to more than 160 publications annually (Ragnarsson, 2006).

Systematic reviews (Chesnut, 1999; Gordon et al., 2006) of research in TBI rehabilitation have identified a number of difficulties which clinicians and researchers in this field face. Firstly, because brain injuries are very complex and variable, no single metric has been developed that is able to accurately indicate the severity of the injury, and relate this to expected impairments, rehabilitation needs and outcome. Thus two individuals with the same severity may have very different patterns of impairment, with different prognoses and different rehabilitation needs. Secondly, impairments that commonly result from TBI pose unique methodological problems in rehabilitation: For example individuals with memory impairments may miss appointments because they forget them, and individuals with executive functioning deficits may lack the insight to appreciate their need to comply with treatment. Another challenge to researchers in TBI rehabilitation is that, although it is one of the most frequent causes of disability, it does not have the high profile accorded to diseases such as breast cancer and Alzheimer's disease. Consequently few resources are allocated for research.

Despite these and other difficulties, progress has been made on a number of fronts. Evidence has accrued for the effectiveness of rehabilitation of TBI interventions for injuries of all severities. For example, in 2005 a Cochrane review (Turner-Stokes, Disler, Nair, & Wade, 2005) looked at the evidence, from randomised controlled trials (RCTs) for the effectiveness of multidisciplinary rehabilitation following acquired brain injury (ABI), in adults of working age, across a range of injury-severity, and found strong evidence that in mild traumatic brain injury (mTBI) most patients make a good recovery with the provision of appropriate information, while for patients with moderate to severe TBI there is strong evidence of benefit from formal intervention.

Secondly, the approach to rehabilitation has moved from a medical focus, which viewed disability as a feature of the person, directly caused by the disease or trauma, to a social model which also considers the psychological and social context in which the person operates. This more comprehensive approach is encapsulated in the World Health Organization's revised framework for health and disability: the International Classification of Functioning, Disability and Health (ICF; World Health Organisation, 2001). Acceptance of this model as the basis for rehabilitation in TBI, and in disability from other causes, has fostered important changes, and it is now acknowledged that rehabilitation is best delivered by well organised, co-ordinated multi- or inter-disciplinary services based on a problem orientated approach (Stucki, Ewert, & Cieza, 2003).

Nevertheless a gap exists between this knowledge base and rehabilitation services available to TBI patients in the community, particularly in areas without a specialist TBI rehabilitation unit. In some countries national guidelines have been developed, for the rehabilitation of TBI, to bridge this gap. However, in many other countries, including Australia, currently there are no national guidelines. This means that rehabilitation pathways may not exist in an area, and, when they do exist, the interventions provided for TBI patients are dependent on the knowledge that available health professionals have about who should be referred to them, and what constitutes effective rehabilitation following TBI. These problems were highlighted by a consensus conference in the United States of America (USA) on the rehabilitation of persons with TBI (National Institutes of Health, 1999), which stated that there is wide discrepancy in the availability of TBI rehabilitation programs across geographic regions, and a lack of knowledgeable professions able to facilitate community-based rehabilitation. The consensus panel also called for more information about non-hospitalised TBI, and pointed out that the epidemiological data on TBI suffer from ascertainment bias, since they are based exclusively on information about hospitalised cases. The panel emphasised that until data are available beyond those based on hospitalised patients, it will not be possible to understand the full spectrum of the disease.

In December 2003, in response to the need for more information about TBI patients across the whole range of injury-severity, the Tasmanian Neurotrauma Register (TNTR) commenced a population-based prospective TBI outcome study, as a joint initiative of the University of Tasmania and the Royal Hobart Hospital (RHH). This project was funded by the Motor Accidents Insurance Board from 2003 until 2008. Prior to this, the incidence of TBI in Tasmania had not been examined.

Tasmania, one of six states in Australia, is an island with a population of 500,000 and one tertiary referral centre, the RHH. The TNTR project attempted to recruit all individuals over the age of 16, including those not admitted to hospital, who presented following a TBI to the Emergency Department (ED) at the RHH. Outcome data were collected from participants at baseline, one month, three-months, six-months, twelve-months, and then annually for up to five years.

The establishment of this database and research programme provided the opportunity to look at patterns of referral to rehabilitation in a population-based sample which included injuries across the spectrum of severity from minimal to very severe. Moreover, the collection of demographic and injury-related information very close to injury, and scores on a wide range of measures at regular intervals post-injury, provided data by which to assess those that accessed rehabilitation services in the community. The present research used this opportunity to examine a wide range of variables in this large (N = 1226) population-based sample and investigate how they were related to their referral or non-referral to post-acute rehabilitation services. Collaboration with the Community Rehabilitation Unit (CRU), enabled this research to describe the rehabilitation process, in all TNTR participants referred for public post-acute rehabilitation, over a three-and-a half-year period.

This research has three overall aims:

- To investigate patterns of referral to post-acute rehabilitation services in the TNTR sample;
- to look at a range of demographic, injury-related and post-injury factors in those referred to public post-acute community rehabilitation, and investigate how they were related to their progress in rehabilitation; and
- to increase understanding of TBI and its management, by developing a model of rehabilitation pathways, based on the TBI rehabilitation literature, summarised in chapters 2 to 5 of this thesis, and the findings of the current research.

The structure of this thesis

Chapters 2 to 5 of this thesis provide an introduction to TBI and its rehabilitation and review the literature related to it, as follows:

- **Chapter 2** provides an overview of the pathophysiology and epidemiology of TBI, the criteria used to categorise its severity, and information about the sequelae and outcome of injuries across the spectrum from mild to severe.
- **Chapter 3** looks at a range of factors which may influence outcome following TBI. To give coherence, the variables considered are characterised as demographic (age, gender, education and pre-morbid IQ), injury-related (injury-severity, cause of injury, previous TBI, hospitalisation), and post-injury (post-concussion symptoms, anxiety, depression, functional dependence, disability, cognition). This chapter also includes information about some of the scales and instruments, used to measure these variables, and includes, where relevant, research findings about their reliability and validity.
- **Chapter 4** outlines the history of rehabilitation for TBI from the early pioneers at the beginning of the 20th century up to the present day. In so doing, it documents some of the important issues that have faced researchers and clinicians. These include the need for standard diagnostic criteria for mild traumatic brain injury (mTBI), the debate about the genesis of post-concussion syndrome, and the development of standards and guidelines for TBI rehabilitation. This chapter also gives an overview of treatment interventions, and evidence for their efficacy, in patients with injuries of all severities, and outlines some limitations in the body of research, which the research reported in this thesis aimed to address.
- **Chapter 5** presents a review of information about rehabilitation services for TBI. It outlines current thinking about rehabilitation in general, including a very brief overview of the World Health Organisation's current framework for health and disability: The International Classification of Functioning, Disability and Health (ICF; World Health Organisation, 2001). This chapter looks at the various stages

of rehabilitation and identifies issues that are unique to the rehabilitation of individuals with TBI. Research documenting service use post-TBI is also summarised in this chapter. The second half of the chapter deals with the organisation of rehabilitation teams, and gives an outline of rehabilitation services in Tasmania during the period of the current research.

Chapters 6 to 10 report on the current research which is divided into five separate studies as follows:

- **Study 1 (Chapter 6)** of this thesis, addresses the first aim of this research, which was to investigate patterns of referral to post-acute rehabilitation services in the TNTR sample. This study details the characteristics of the participants of the TNTR research project, which, as described above, is an adult, population-based, prospective, traumatic brain injury outcome study located in Hobart, the capital city of the Australian state of Tasmania, and investigates how those characteristics relate to their referral or non-referral to post-acute rehabilitation services following their injury. A wide range of variables are examined in this study including demographic (age, gender, education and estimated premorbid IQ), injury-related (injury-severity, cause of injury, previous TBI, hospitalisation), cognitive (measures of executive functioning, working memory and information processing speed) and post-injury variables (post-concussion symptoms, pain, fatigue, anxiety, depression, functional dependence, disability, employment status).
- **Study 2 (Chapter 7)** of this thesis, and the subsequent three studies, study 3, study 4 and study 5, address the second aim of the research, by examining a range of demographic, injury-related and post-injury variables in the sub-sample of TNTR participants referred to public post-acute community rehabilitation at the

Community Rehabilitation Unit (CRU) in Hobart, and investigating how they were related to their progress in rehabilitation. Study 2 considers how the demographic variables of age, gender, education and estimated premorbid IQ were related to the sample's referral to CRU’s seven clinical disciplines, how they impacted on the probability of being offered an initial appointment and, for those offered one, to the probability of attending it. The relationship between these demographic variables and service utilisation is also examined in this study.

- **Study 3 (Chapter 8)** of this thesis, examines the referred sample and investigates how the injury-related variables of cause of injury, previous TBI, injury-severity, and hospitalisation were related to their referral to CRU’s clinical disciplines, how they impacted on the probability of their being offered an initial appointment and, for the cohort who were offered one, to the probability of their attending it. The relationship between these injury-related variables and service utilisation is also examined.
- **Study 4 (Chapter 9)** of this thesis, investigates the referred sample and examines how the post-injury variables of post-concussion symptoms, anxiety, depression and functional dependence were related to referral to CRU’s clinical disciplines, how they impacted on the probability of being offered an initial appointment and, for the cohort who were offered one, to the probability of attending it. The relationship between these post-injury variables and service utilisation is also examined.
- **Study 5 (Chapter 10)** is the last study reported in this thesis. This study aimed to measure the amount and nature of therapy participants received in CRU’s seven clinical disciplines, and to consider how the range of variables examined in studies 2, 3 and 4 affected these therapy variables. Other factors relating to

participants' rehabilitation at CRU, such as wait-times from their referral to being contact by a clinician in individual disciplines and wait-times to their being offered an appointment, are also considered in this study.

The final chapter in this thesis, chapter 11, summarises and integrates the main findings from the five studies and discusses their implications for further research and for clinical practice. This chapter also addresses the third aim of the current research which is to increase understanding of TBI and its management, by developing a model of rehabilitation pathways based on the literature reviewed in chapters 2 to 5, and the results of the studies reported in chapters 6 to 10 of this thesis. A diagram of the proposed model is given in figure 11.3, and a description of it is outlined in this chapter. The limitations of the current research and suggestions for future research are also included in this chapter.

CHAPTER 2 - Traumatic Brain Injury

2.1 Definition

Traumatic brain injury (TBI) occurs when an external force traumatically injures the brain. It may be divided into:

- Penetrating brain injuries resulting from an object wounding the brain.
- Closed head injuries resulting from a blow to the head by a blunt object, the impact of the head with a stationary object or the rapid deceleration of the head, which may occur without contact with an external object.

The Centres for Disease Control and Prevention in USA provide a standard clinical case definition of TBI, which has been summarized as:

> ... an occurrence of injury to the head (arising from blunt or penetrating trauma or from acceleration-deceleration forces) that is associated with symptoms or signs attributable to the injury: decreased level of consciousness, amnesia, other neurological or neuropsychological abnormalities, skull fracture, diagnosed intracranial lesions—or death. (Thurman & Guerrero, 1999, p. 603).

2.2 Terminology

In the early literature, the terms *head injury* and *brain injury,* are often used synonymously. Although head and brain injuries often occur in combination, an individual can sustain an injury to the head without the brain being injured, and a brain injury can take place without injury to the head. In 1992, following recommendations from a consensus conference on mTBI sponsored by the National Institute of Disability and Rehabilitation Research in USA, head injury was defined as an injury to any part of the head—for example the face—whereas brain injury denotes damage to the brain (Kay, Newman, Cavallo, Ezrachi, & Resnick, 1992). This distinction led many organisations in the field to change their names in order to include the term brain injury. For example the National Head Injury Foundation in USA became the National Brain Injury Association. However many clinicians continue to use the term head injury or head trauma.

Concussion is a general term, usually defined as a disturbance in neurological function caused by acceleration/deceleration forces. Although concussion can refer to a range of injury-severity, it is rarely used for severe TBI.

2.3 Pathophysiology

The mechanisms of brain injury can be separated into primary injury and secondary injury. Primary injury occurs as a direct result of the trauma: secondary injury, as a result of complications of the original injury.

2.3.1 Primary injury.

A penetrating brain injury typically produces a focal brain lesion, with laceration and damage to the brain tissue by the projectile itself and, in the case of a high-velocity object such as a bullet, from stretching and crushing due to the shock waves the projectile creates.

In closed head injuries, a blow to the head, the impact of the head with a stationary object, or the rapid deceleration of the head without contact with an external object—in for example a car accident—results in haemorrhagic lesions, called contusions, as the brain comes into contact with the skull. Contusions may be at the sight of the blow, but are also often found on the side of the brain opposite to it, with the most common sites, irrespective of the site of the impact, being the frontal and temporal regions of the brain (Ponsford, 1995). Cortical contusions can lead to secondary complications, such as brain swelling, oedema (extracellular fluid accumulation), and local ischemia (restriction in blood supply), but do not cause initial loss of consciousness (LOC).

Acceleration/deceleration forces are considered to be an important factor in the genesis of TBI and in LOC. These forces are sufficient to cause severe injuries without actual trauma to the head, in for example motor vehicle accidents, or infants with "shaken baby syndrome". They rarely cause shearing of neurons, but instead, initiate a pathophysiologic process, with a well-defined temporal progression. At the moment of impact, brain cells are stretched and damaged, and this sets in motion pathological changes in the cell bodies over the subsequent hours and days, in a process known as traumatic axonal injury (Gaetz, 2004). Mechanical strains are thought to operate in a "centripetal sequence" whereby mild forces cause damage to the white matter near the surface of the brain, while more severe forces progressively affect deeper structures (Ommaya & Gennarelli, 1974). This suggests that mild, moderate and severe brain injuries caused by acceleration/deceleration forces are not discrete entities, but occur on a continuum ranging from the damage to the surface of the brain to damage of deeper structures as forces increase (Gaetz, 2004). Animal studies indicate that the direction of the force can also determinate the severity of injury, with sagittal (front-to-back) injuries resulting in good recovery, while lateral injuries (side-to-side) result in persistent coma or severe disability, and oblique injuries fall in-between (Gennarelli, Thibault, & Adams, 1982).

2.3.2 Secondary injury.

Following the initial injury, secondary brain injury may occur as a consequence of:

- Intracranial complications: these include intracranial haematoma (a localized collection of blood outside the blood vessels), caused by tearing of blood vessels at the time of the impact, brain swelling, as a result of increased cerebral blood volume or oedema, infection, and raised intracranial pressure.

- Extra-cranial complications: these include hypoxia (shortage of oxygen) and hypotension (low blood pressure) resulting from blocked airways or poor blood supply, due to trauma to other parts of the body.

The most significant factor in secondary brain damage is ischemia, caused by inadequate blood flow or a raise in intracranial pressure (Gaetz, 2004). Ischemia has been shown to result in a cascade of inflammatory and cytotoxic (any process which is toxic to cells) mechanisms which may result in tissue damage and cell death (Gennarelli, 1993).

Intracranial pressure, haematoma and brain swelling may also cause complications, such as compression of the oculomotor nerve or mid brain dysfunction. In severe injuries, compression of the brain stem may occur which, if unchecked, leads to death.

2.4 Incidence

Incidence can be defined as the number of new cases of a condition diagnosed or reported during a specified time period, usually one year (Pol & Thomas, 1992, quoted in Fortune and Wen, 1999). Differences in operational definitions and study methodologies affect incidence estimates for TBI, so differences between estimates may reflect both real variations in the rate of injury between countries or regions over time and/or differences in methodology.

It is important to note that the majority of studies use hospitalisations as indicative of incidence of TBI, and there have been very few TBI incidence studies which have included non-hospitalised cases. Although people who present to hospitals after TBI but are not admitted make a considerable impact on the health care system

(Jennett, 1998) no routine statistics are published for accident and emergency departments, and they are not included in incidence studies based on hospitalisations.

The Australian Institute of Health and Welfare review estimates of acquired brain injury (ABI) both overseas and in Australia in order to give a “reasonable range” of incidence estimates (Fortune & Wen, 1999). Although ABI is a broader term than TBI, and covers brain injury from a number of causes, including hypoxia, infection and stroke, TBI is the main, or sole, focus of the majority of studies reviewed. Focusing on studies that used data from a number of hospitals, and which were not restricted in age, they give a range from 101 to 281 per 100,000 per year for incidence overseas, and a range of between 100 and 377 per 100,000 for Australia. This broad range of estimates highlights the uncertainty surrounding the field.

Among adults, incidence rates for TBI are highest among persons 15-24 years of age, and there are about two males injured for every female. This is reflected in figures from the National Hospital Morbidity Database, a collection of summary records for patients admitted to Australian hospitals published by the Australian Institute of Health and Welfare (Fortune & Wen, 1999). In the year 1996-7 (i.e. July 1996-June 1997) there were 27,437 hospital separations in Australia with a diagnosis of TBI, an incidence rate of 149 per 100,000. Almost 70% of these separations were males, with a higher rate for males compared to females in all age groups. The male to female rate was highest for people aged between 15 and 29 years with a peak in the age group 20 to 29 years. The highest age specific rate was for the groups aged 0 to 4 years, 15 to 19 years and over 85 years, and this pattern was similar for both males and females. Almost 60% of hospital separations were people of working age (i.e. aged 15-64). A more recent report from the Australian Institute of Health and Welfare (Helps, Henley, & Harrison, 2008) giving data from 2004-5 found that hospitalisation separation rates for TBI as a principal diagnosis had remained stable, but there was a 7% increase for TBI as an additional diagnosis.

2.5 Prevalence

Prevalence is the total number of cases of a disease in the population at a given time, or the total number of cases in the population, divided by the number of individuals in the population. It is a measurement of all individuals affected by a disease within a particular time-period, or at any moment in time.

Prevalence rates for TBI give an indication of the total number of people with long-term disability attributable to TBI in a country or area. Data on TBI prevalence in Australia, published by the Australian Institute of Health and Welfare (Fortune & Wen, 1999), include widely different rates, due to different operational definitions and methodologies in different studies. Furthermore most of the Australian studies are of acquired brain injury and include stroke and other forms of brain damage as well as TBI. Some of the overseas studies, are of TBI only, but prevalence estimates vary from a minimum of 100 per 100,000 in a study in the United Kingdom of Great Britain and Northern Ireland (UK) to a maximum of 783 in a study in China (Fortune & Wen, 1999).

Some authors have attempted to estimate the percentage of people with newly diagnosed cases of TBI who will go on to experience long-term disability. Kraus (1987), (cited in Fortune & Wen, 1999, p 76) reviewed several studies of incidence and concluded that, as a reasonable generalisation, 80% of hospitalised TBI cases were mild injuries, 10% were moderate, and 10% were severe, and slightly smaller percentages of each category would be discharged alive after the TBI. Kraus assumed that 10% of people with mTBI, 33% with moderate TBI and 100% with severe TBI would go on to experience long-term disability. From these figures he estimated that 16.4% of people with newly diagnosed TBI, who are discharged alive from hospital, will go on to experience long-term disability. This figure is in line with a study in South Australia (Hillier, Hiller, & Metzer, 1997) that reports on outcome at hospital discharge for adults with TBI of all severities, and gives a figure of 15% as the proportion of people needing in-patient rehabilitation.

Fortune and Wen (1999), applying Kraus's formula to the 1996-7 incidence rate of hospitalised TBI in Australia (27,437 hospital separation) quoted in the preceding section, estimated an annual rate of long-term disability from TBI in Australia to be 24 per 100,000. Tasmania with a population of 500,000 in December 2008 (Australian Bureau of Statistics, 2011) can therefore expect to have an annual rate of long-term disability from TBI of approximately 120. However, as the majority of TBI cases are not hospitalised and a proportion of non-hospitalised cases suffer ongoing problems (Wade, King, Wenden, Crawford, & Caldwell, 1998) the actual rate of long-term disability following TBI is likely to be considerably higher than these estimated figures.

2.6 Cause

A systematic review of TBI epidemiology in Europe by Tagliaferri, Compagnone, Korsic, Sevadei and Kraus (2006) gives data on external cause or mechanism of injury from thirteen studies. Two thirds of these show motor vehicle/traffic related accidents as the most common cause of injury. Second in frequency, and in a few reports the most common cause, was falls. One study from Scotland found violence to be a common cause accounting for 28% of injuries. Only four studies give data for sporting injuries, and all of them found these injuries to account for less than 10% of the total. However research has suggested that the incidence rate for sporting injuries is difficult to measure, because most injuries are mild and do not result in hospital admission. Furthermore athletes may under-report symptoms in order to resume play (Carroll et al., 2004b).

A similar pattern of cause of injury was found in a study of the incidence and nature of TBI in South Australia (Hillier, et al., 1997). State-wide summaries of hospital separations from all public and private hospitals found transport accidents accounted for 57% of TBIs, with falls the second major cause at 29%. Cause varied according to gender, with males being more likely to sustain their injury from an assault, or as a rider of a motor bike, and females being more likely to be passengers in a motor vehicle. Data for sporting injuries were not reported.

The most recent report of hospital separations in Australia due to TBI (Helps, et al., 2008) found that, in cases where TBI is the principal diagnosis, falls where the most common cause (42%), followed by transportation (29%) and assault (14%). Where TBI was an additional diagnosis, transportation (42%) was higher than falls (30%). More females than males sustained TBI caused by falls; and much higher numbers of males than females sustained TBI caused by assault. Transportation accounted for equal proportions of TBI among males and females.

A study by Tate and colleagues (1998) in New South Wales also found that road traffic accidents accounted for the highest proportion (40%) of injuries, with falls making up one-fifth of cases. Falls were the most common cause of injury in the elderly, accounting for 76% of the age group 75 years and above. This is consistent with a study by Kraus et al. (1984) which reported a sharp increase in the rate of TBI caused by a fall in the 65-and-older age group. Studies of TBI in older adults both overseas (Thompson, McCormick, & Kagan, 2006) and in Australia (Kinsella, 2011), have also reported falls as the most common cause of injury in this age group.

2.7 Severity of Injury

The criteria used to distinguish mild from moderate and severe TBI are duration of loss of consciousness (LOC), depth of coma and/or the length of time that the person is assessed to be experiencing post-traumatic amnesia (PTA).

Numerous systems have been developed to classify TBI severity on a continuum from mild to moderate to severe. Historically the presence and duration of LOC, measured in minutes, hours or days, has been the main point of distinction between TBI severities. However LOC may not always correlate with injury-severity, and a considerable number of people who do not lose consciousness have poor outcomes (Hanlon, Demery, Martinovich, & Kelly, 1999; Ruffolo, Friedland, Dawson, Colantonio, & Lindsay, 1999).

Another way of classifying injury-severity is depth of coma as measured by the Glasgow Coma Scale (GCS; Jennett, 1976) an observational instrument used to evaluate eye opening, verbal responses and motor response with a score ranging from 3 to 15. A convention has emerged (Jennett, 1998) that patients with a coma score of 8 or less are classed as severe, and those with a score of 13 or more as mild, the others being classed as moderate.

Post traumatic amnesia (PTA) was defined by Russell and Smith as the period after head injury during which information about ongoing events is not stored (Russell & Smith, 1961a). PTA includes the period of coma and extends until the injured individuals memory is reliable, consistent and accurate. Russell and Smith in their original paper suggested that an injury with less than one hour PTA be considered a *slight concussion* whereas a *moderate concussion* was one to 24 hours and a *severe concussion* was 1—7 days. These categories of severity continue to be used by some researchers (for example Tate, et al., 1998; Wade, et al., 1998).

2.8 Mild TBI

A best evidence synthesis of the world literature on mild TBI (mTBI) by the World Health Organisation (WHO) Collaborating Centre Task Force on Mild Traumatic Brain Injury suggests that 70% to 90% of all treated TBIs are mild and the incidence of hospital treated patients with mTBI is about 100—300/100,000 population (Cassidy et al., 2004b). However because many mild injuries are not treated in hospitals, these researchers estimated that the true population-based rate is probably above 600/100,000.

Different definitions and diagnostic criteria have made it difficult to compare research into the incidence, outcomes and rehabilitation interventions for mTBI. In particular, many clinicians believe that it cannot be diagnosed without a period of LOC. However, in 1993 the Mild Traumatic Brain Injury Committee of the Head Injury Inter-disciplinary Special Interest Group of the American Congress of Rehabilitation Medicine (ACRM) developed diagnostic criteria (Kay et al., 1993), which do not require LOC to be present for TBI to be diagnosed. These criteria state that a patient with a mild traumatic brain injury (mTBI) is a person who has a traumatically induced physiological disruption of brain function, as manifested by at least one of the following:

- any period of LOC,
- any loss of memory for events immediately before or after the accident,
- any alteration in mental state at the time of the accident (e.g. feeling dazed, disoriented, or confused); and focal neurological deficit(s) that may or may not be transient;

but, where the severity of the injury does not exceed the following:

- LOC of approx. 30 minutes or less;
- after 30 minutes, an initial GCS of 13-15; and

- PTA not greater than 24 hours.

Prior to this TBI was usually only diagnosed if a period of LOC was observed. However the ACRM definition, supported by ongoing research, has led to acceptance that LOC is not essential for diagnosis of mTBI. Using this definition, an injury with PTA of more than 24 hours but less than one week is usually considered moderate, and severe TBIs are those with PTA of more than one week.

If a patient has a skull fracture, focal neurological deficits or hemiparesis the injury is not usually considered mild, although if it meets the definition of a mild injury described above it may be classified as a complicated mTBI. In most studies, patients with complicated mTBIs perform more poorly on neuropsychological tests in the initial period (Iverson, 2006). It is important to note that criteria for defining a brain injury as mild are not necessarily compatible. For example a person may meet the GCS criteria for mTBI but have PTA of more than 24 hours. This has resulted in some confusion in the literature and a call for a universally accepted definition of mTBI, based on valid diagnostic criteria (Carroll, Cassidy, Holm, Kraus, & Coronado, 2004a; von Holst & Cassidy, 2004).

2.9 Sequelae and Outcome Following mTBI

Recovery following TBI occurs over an extended period. In general, outcome has been related to the severity of brain injury, and the sequelae of mild, moderate and severe TBI are differentiated in the literature (Goldstein & Levin, 2001; Hellawell, Taylor, & Pentland, 1999; Ruff et al., 1993).

MTBI has been termed a "silent epidemic" (Tellier et al., 1999) because of its high prevalence and, often unrecognised, consequences. It tends to result in a range of cognitive sequelae, including problems of recall of material, speed of information processing and attention, which can be identified through neuropsychological testing

(Bazarian et al., 1999; Macciocchi, Barth, Alves, Rimel, & Jane, 1996). It may also result in a range of symptoms including headache, dizziness, fatigue, irritability, sensitivity to noise and/or bright lights, blurred or double vision; restlessness, irritability, insomnia, anxiety and depression. These symptoms are known as post-concussion symptoms (PCS): The most commonly reported ones are headaches, fatigue, forgetfulness and sleep difficulties. (Carroll, et al., 2004b).

PCS are not unique to mTBI and have been reported in individuals with other conditions, such as chronic pain (Iverson & McCracken, 1997), but they are more common following mTBI than after other injuries, or in the general population (Bazarian, et al., 1999; Paniak et al., 2002). Because few studies have used an injured control group, and even fewer have compared pain and distress between a mTBI group and controls, these factors may play a role in the observed cognitive deficits and self-reported symptoms following mTBI (Carroll, et al., 2004a).

There is strong evidence that a single uncomplicated mTBI produces no permanent disabling neurobehavioral impairment, in the great majority of patients who are free of pre-existing neuropsychiatric disorders and substance abuse (Dikmen et al., 2009; Levin, Mattis, & Ruff, 1987). Symptoms are largely resolved within three months in the majority of cases (Carroll, et al., 2004b). However a number of studies have indicated that a sub-group of mTBI patients continue to experience cognitive difficulties, physical symptoms and psychosocial poor outcomes for months, or even years post-injury (Binder, 1986b; Ponsford et al., 2000; Rutherford, Merrett, & McDonald, 1979). When this cluster of PCS is persistent it is often referred to as post-concussion syndrome (a syndrome is a set of signs and/or symptoms that appear together and characterise a disease or medical condition). Although a figure of 20% of mTBI cases resulting in post-concussion syndrome is often quoted in the literature, some researchers have suggested that 5% is a more realistic estimate of its incidence (Iverson, 2005; McCrea, 2008).

2.10 Post-concussion Syndrome

For decades researchers have attempted to define whether post-concussion syndrome is a true syndrome or disease entity, and questioned the role of financial compensation in its aetiology (Binder & Rohling, 1996; Cook, 1972; Reynolds, Paniak, Toller-Lobe, & Nagy, 2003). Many studies have reported that those injured in sport recover faster than those injured by other means. While subjective symptoms may be under-reported by athletes who want to return to play, studies that also use objective measures are harder to explain: For example McCrea et al. (2003) in a prospective study found that 91% of a sample of 79 football players returned to baseline functioning on cognitive tests, within seven days of concussion.

Both physiological and psychological aetiologies have been suggested as a cause for post-concussion syndrome and this has led to much debate in the literature (King, 2003; Ruff, 2005). Evidence that the syndrome is primarily organic includes post-mortem studies demonstrating diffuse microscopic axonal injury after mTBI (Oppenheimer, 1968) , macroscopic brain lesions on computed tomography (CT) or magnetic resonance imaging (MRI) brain scans performed post-injury (Levin, Williams, Eisenberg, High Jnr, & Guinto Jnr, 1992) and abnormal regional cerebral blood flow in a number of individuals who had demonstrable high functioning prior to a mTBI, but persistent difficulties after it (Varney et al., 1995). Evidence for the involvement of psychological factors include studies which demonstrate worse outcome where there is pre-existing psychopathology (Mooney & Speed, 2001), high rates of comorbid anxiety and depression symptoms (King, 2003) and the association between severity of symptoms and compensation and litigation issues (Binder & Rohling, 1996). There is generally some consensus that both physiological and psychological factors play a part in post-concussion syndrome (Lishman, 1988). Physiological factors are likely to start the process in the days following a mTBI. During the subsequent few months psychological features can develop, particularly in those with pre-existing psychological vulnerabilities. These psychological factors and other psychosocial and non-mTBI specific factors are most likely to responsible for the maintenance of the syndrome (McCrea, 2008).

In exploratory studies, female gender, a history of pre-existing physical limitations, prior to TBI, litigation and compensation issues, neurological or psychiatric problems and older age have all been identified as possible predicators of post-concussion syndrome. In 2004 the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury published a review of the evidence relating to prognosis following mTBI. This review identified numerous methodological issues in the mTBI research, such as a lack of control groups and inadequate consideration of the possible confounding effect of other factors. However it found that the best evidence consistently suggests there are no mTBI attributable, objectively measured, cognitive deficits beyond one to three months, in the majority of cases. Self-reported symptoms are common, but there is little consensus about how long they last. Studies of sporting injuries suggested that they resolve quickly, but it could be argued that athletes under-report because they want to resume play. For other populations, where symptoms persist there is evidence that compensation/litigation issues play a role, but there is little consistent evidence for other predictors (Carroll, et al., 2004a).

Persistent PCS have been found to be a strong predictor of poor psychosocial outcomes for months, or even years, post-injury (Alexander, 1992), and to impair return-to-work and psychosocial functioning (Dikmen, Temkin, & Armsden, 1989).

2.11 Outcome Following Moderate to Severe Injuries

PCS may also occur following moderate and severe TBIs, but tend to be not well documented. One review reported 31% of those suffering a moderate-to-severe injury report symptoms at six months post-injury (Mittenberg & Strauman, 2000). It is noteworthy that, whereas PCS in mild injuries tends to decline over time, individuals with severe TBI tend to increase self-reported PCS symptoms (Gordon, Haddad, Brown, Hibbard, & Sliwinski, 2000; Sigurdardottir, Andelic, Roe, Jerstad, & Schanke, 2009). This may be because in the early stages of their injury, they are less aware of their deficits for organic reasons.

Severe injuries may also result in a wide range of more-lasting changes. Physical problems are largely related to the location and extent of the injury, and may include weakness or paralysis on one or both sides of the body, ataxia, and poor balance. There may also be reduced control over bowels and bladder. Cranial nerve damage, and damage to the sensory pathways, may result in disruptions of vision, hearing, smell or taste. Swallowing deficits and loss of taste may also occur due to damage to the glossopharyngeal nerve (Ponsford, 1995).

Cognitive problems following moderate and severe TBI can result in difficulties in attention, episodic memory, executive functions (such as higher-order planning, initiating and directing, monitoring, problem-solving and inhibitory control), working memory, information-processing speed, language functions, and visuospatial processing (Dikmen, et al., 2009). Changes in emotional response may result in depression, anxiety, fear, anger and frustration, while common behaviour changes include apathy, irritability, aggressive and/or socially inappropriate behaviour, restlessness and agitation and difficulty relating to others (Ponsford, Olver, Curran, & Ng, 1995). In the longer-term TBI increases the risk of seizures, psychotic disorders and dementia (Gualtieri &

Cox, 1991). However, studies of long-term outcome indicate that, in the majority of cases, it is the cognitive and behavioural, rather than the sensorimotor or physical impairments, which are the most disabling (Hoofien, Gilboa, Vakil, & Donovick, 2001; Ponsford, et al., 1995).

2.12 Summary and Research Directions

In summary, traumatic brain injury (TBI) occurs when an outside force traumatically injures the brain, and may be divided into penetrating and closed head injuries. A penetrating brain injury typically produces focal brain lesions from the projectile and the shockwaves it creates. Closed head injuries result in contusions, most commonly in the frontal and temporal regions of the brain. Acceleration/deceleration forces are considered an important factor in the genesis of TBI and LOC. Mild forces cause damage near the surface of the brain, and more severe forces progressively affect deeper structures, suggesting that mild, moderate and severe acceleration/deceleration injuries occur on a continuum. The direction of the force may also be a determinant of severity with lateral injuries causing more severe coma and disability. Secondary injuries result from intracranial and/or extra-cranial complications of the original injury. The most significant factor in secondary injury is ischemia, caused by inadequate blood flow or a raise in intracranial pressure. TBI incidence rates are reported to range from 100 and 377 per 100,000, but it is important to note that these estimates do not include non-hospitalised cases. The true population-based incidence rate may be more than 600 per 100,000. Among adults, incidence rates are highest among persons aged 15 to 24 years and the most common causes of injury are motor vehicle accidents and falls. The Australian Institute of Health and Welfare (Fortune & Wen, 1999) give an estimate an annual rate of long-term disability from TBI of 24 per 100,000 in Australia, but as this does not include non-hospitalised cases the actual rate of disability is likely to be considerably higher. The main causes of injury in epidemiological studies in Australia and overseas are motor-vehicle related accidents and falls.

Different definitions and diagnostic criteria have made comparison of mTBI studies difficult. Many clinicians believe that it cannot be diagnosed without a period of LOC. However, in 1993, the Mild Traumatic Brain Injury Committee of the Head Injury Inter-disciplinary Special Interest Group of the American Congress of Rehabilitation Medicine (ACRM) put forward standard diagnostic criteria, which have been widely accepted. This definition, supported by ongoing research, has led to acceptance that LOC is not essential for the diagnosis of mTBI.

MTBI has been termed a silent epidemic because of its high prevalence and often unrecognised consequences. It may result in a range of signs and symptoms known as post-concussion symptoms (PCS). In the majority of cases PCS resolve within three months but a sub-group of cases may experience persisting symptoms. Both physiological and psychological aetiologies have been suggested as a cause for persisting PCS, and there is some general consensus that both factors play a part. More severe TIB may result in a wide range of more lasting changes, including physical problems, cranial nerve damage—which may disrupt hearing, smell and taste—and problems with attention, memory information-processing speed, language functions, and visuospatial processing. Changes in emotion and behaviour are also common following moderate and severe injuries. In the majority of cases it is the cognitive, behavioural and emotional problems that cause the most long-term problem following TBI.

One of the aims of the current research was to increase understanding of TBI and its management, by developing a model of rehabilitation pathways. To lay the foundation of such a model, chapter 3 of this thesis will consider some of the factors that have been shown to influence outcome following TBI and chapters 4 and 5 will delineate approaches to TBI rehabilitation and the research that informs them, and gives an overview of rehabilitation services available in Tasmania during the period of the current research. The present chapter has highlighted the following challenges that TBI presents to rehabilitation services, which need to be considered when developing such a model:

- TBI has a peak incidence in young people, a proportion of whom will need ongoing support for many years, or in severe cases, for the rest of their lives.
- In contrast with many other chronic conditions, the majority of adults who sustain a TBI are of working age, making employment and productivity, important measures of outcome for this population.
- Different patients will present with different combinations of difficulties, because of the heterogeneous nature of disabilities resulting from TBI, which include physical, cognitive, emotional and behavioural difficulties.
- Although most people with mild injuries will recover within three months, a proportion will have ongoing difficulties requiring assistance from rehabilitation services.
- Because 80% to 90% of TBI cases are mild the numbers of mTBI cases that can benefit from follow-up are significant.
- Identification of the mTBI patients most likely to require assistance would greatly assist the planning and implementation of appropriate and timely rehabilitation interventions.

CHAPTER 3 - Variables that Relate to Outcome following Traumatic Brain Injury

Many factors influence outcome following TBI. This chapter will review the literature relating to those most relevant to the current research. To give coherence, the variables considered are characterised as demographic (age, gender, education, estimated pre-morbid IQ), injury-related (injury-severity, cause of injury, previous TBI, hospitalisation), and post-injury (PCS, anxiety, depression, functional dependence, cognition). Where relevant, information about the instruments used to measure the different variables is included.

A significant amount of the TBI literature deals with the acute prognostic implications of clinical and laboratory parameters, such as Magnetic Resonance Imaging (MRI) findings, and evidence of hypoxic or anoxic injury (Zasler, 1997). Consideration of this body of research is beyond the scope of the current research. In general it is also not applicable for most of the participants of population studies, which typically include many individuals with injuries at the milder end of the spectrum, for whom these types of investigations are not usually considered appropriate or necessary.

3.1 Demographic Variables

3.1.1 Age-at-injury.

The relationship between age at the time of injury and outcome after TBI has been investigated by many studies, most of which have found that poorer psychosocial, cognitive and functional outcomes are experience in older TBI patients (Goleburn & Golden, 2001). For example in a study of 411 individuals, aged 18 to 89 years, hospitalised with mild to severe TBI, Rothweiler, Temkin and Dikmen (1998) found increasing age is associated with increasing levels of psychosocial limitations, especially in persons 60 years of age and older. A study by Whiteneck et al. (2004a) of 1591 adults with moderate and severe TBI found that, although individuals over 65 years had the lowest percentage of reported symptoms, they had more need for assistance and reported poorer quality of life than younger individuals. Assessment of community integration and participation found that, the 16 to 24 year age group had the lowest percentage of members showing decreased participation, while increasing age was associated with a higher percentage of handicap. In general persons over age 65 had poorer outcomes.

Keyser-Marcus et al. (2002) in a study of 538 rehabilitation inpatients seen at one to five years post-injury found that, for up to four years post-injury, age appeared to be the most reliable predictor of whether an individual would work or attend school, with individuals aged 40 and older significantly less likely to be employed compared to younger TBI patients.

One possible reason for these results is that older people sustain injuries of greater severity of injury, as reflected by length of coma, despite equivalent initial GCS scores (Rothweiler, et al., 1998). However Susman et al. (2002), in a strong study with a large number of participants, compared data from a state-wide data set for older TBI patients (age > 64 years) with data from younger patients (age > 15 and < 65 years) with similar injuries, and found that older TBI patients had higher mortality and poorer functional outcome than younger TBI patients, even in those patients whose injuries are mild. The total number of patients in this study was 11,722, of which 3,244 (27%) were in the older age group.

Vollmer et al. (1991) attempted to better characterize the relationship between age and outcome in severe injury in 661 patients aged 15 years or older, by prospectively following them using the Glasgow Outcome Scale (GOS; Jennett & Bond, 1975) to measure outcome. Older patients had higher rates of mortality overall, although survival rates within the first 48 hours post-injury did not differ significantly with age. After this time period, major differences were observed, with patients older than 55 years disproportionally more likely to die between 48 hours and 10 days compared with younger patients. As GCS scores, did not significantly differ according to age, injury-severity did not explain these differences. Falls and pedestrian accidents occurred with greater frequency in older patients, and multiple injuries were less common in this group. There are many factors associated with age, such as more frequent systemic complications or pre-existing illness, which might explain poorer outcome in the older patient. To determine the relative significance of such clinical factors these researchers (Vollmer, et al., 1991) performed a multivariate logistic regression analysis on their data and found age to be an independent predictor in the model. The authors conclude that, based on this analysis, it is likely that the effect of age on outcome following TBI is dependent upon an alteration in the pathophysiologic response of the aging central nervous system to severe trauma, and not an increased incidence of non-neurological complications or other clinical parameters.

A review of the literature on outcome in older adults following TBI (Goleburn & Golden, 2001) found secondary brain injuries, such as subdural haematomas, and extra-cranial medical complications, such as pneumonia, were more common in this age group. Older adults (i.e. those over the age of 65 years) had an increased risk for a negative outcome and tended to remain in hospital for twice as long as younger ones. Even mild injuries were associated with significant decreases in mobility and independent functioning. It can therefore be concluded that age has been shown to be an independent predictor of outcome following TBI of all severities, with older people

(> 60 years) experiencing poorer psychosocial, cognitive, functional and employment outcomes than younger ones.

3.1.2 Gender.

Outcome was worse in women on 85% of outcome variables in a meta-analysis by Farace and Alves (Farace & Alves, 2000). The majority of outcome variables were PCS, but one study investigating survival, and another considering length of hospitalisation following TBI, also found outcome was worse in women. There are many possible reasons why difference in outcome might be found in women compared with men. These include premorbid factors, such as IQ, education and employment; difference in the mechanism of injury, differences in brain function and organisation, interaction of sex hormones with TBI sequelae and differences in symptom reporting and rehabilitation interventions. However the authors of this meta-analysis point out that only a small percentage of outcome studies separate results by gender, and prospective studies are needed to study the effect of this variable on outcome following TBI.

Looking at return to work, Crepau and Scherzer (1993) in their meta-analysis found mixed results for the relationship between gender and work status: in studies made up mostly of severe cases, the proportion of women returning to work was slightly greater, while for samples made up of less severe cases the proportion of men, was greater. In a more recent review of 50 empirical studies looking at factors influencing employment outcome after TBI (Ownsworth & McKenna, 2004), found no empirical support for gender differences in any of the studies rated as *acceptable* (meeting 6 or 7 out of 9 criteria) or *commendable* (meeting 8 or 9 of the criteria) and consequently conclude that gender is not a significant predictor of employment outcome following TBI. However Whiteneck et al. (2004a), in a study of population-based estimates of outcomes after hospitalisation for TBI in 1591 adults, found significant differences in return to work rates among groups defined by severity of injury and gender. Women were more likely to report not working at one-year post-injury, were more likely to report symptoms and a need for assistance, and to be handicapped on the short form of the Craig Handicap Assessment and Reporting Technique (CHART-SF; Whiteneck, Charlifue, Gerhart, Overholser, & Richardson, 1992). The reasons why this study found a significant difference in return to work, whereas the review by Ownsworth and McKenna (2004) did not, are not clear. However, as indicated above, the number of studies which include this variable are limited (for example only 5 out of 14 of the studies in the acceptable category report on outcome by gender in the review by Ownsworth and McKenna). More research is therefore needed in this area.

In mTBI, Ponsford et al. (2000) looked at outcomes in 84 adults and found that by three months post-injury symptoms, such as headaches, dizziness and fatigue, had largely resolved and, no impairments were evident on neuropsychological measures for the majority of the group. However there was a subgroup of 24% of participants who were still suffering many symptoms, who were highly distressed and whose lives were significantly disrupted. This group did not differ from the rest of the group, in terms of age, education, socioeconomic status or PTA duration, but there was a higher proportion of females and students. They were also more likely to have had a previous head injury, neurological or psychiatric problems and/or to have been injured in a motor vehicle accident.

Carroll et al. (2004b), in a critical review of 120 studies of prognosis following mTBI, found little consistent evidence for sex as a predictor of outcome. Although some studies identified female gender as a predictor, others found no independent relationship. For example, Bazarian et al. (1999) in a prospective observational study of

71 mild head injury patients and 60 orthopaedic controls found female gender had a higher predictive value than male gender at one month, with a trend to being higher at three and six months as well. On the other hand Cassidy, Carroll, Cote, Holm and Nygran (2004a), in a population-based, cohort study of 479 motor vehicle injury claimants with mTBI, failed to find gender to be independently associated with slower recovery.

In summary few studies report outcome following TBI separately by gender and those that do have produced mixed results. Some outcomes, particularly reporting of post-concussive symptoms, may be worse in women than men, but prospective studies of the natural history of TBI mechanisms and sequelae are needed to further study the relationship between gender difference and TBI outcome.

3.1.3 Education.

Studies of people who were in employment prior to their injury have found that individuals who do not complete high school are more likely to be unemployed following a TBI, than those who completed high school or attended college. For example, in a prospective longitudinal study, Dikmen (1994) compared 366 hospitalised TBI patients who were workers before injury with 95 controls, who had sustained a traumatic injury to the body but not to the head, and found that individuals with less than a high school education were less likely to go back to work than other groups. Similarly Greenspan, Wrigley, Krsnow, Branch-Dorsey & Fine (1996) looking at 343 previously employed persons who were hospitalised following TBI, found that those who had not completed high school were less likely to return to work. Sherer et al (2003) in a large (n = 1083) study of productivity, which included attendance at school and occupation as a full-time homemaker, as well as paid employment, also found that those with less than high school education are vulnerable to poor outcomes.

Multiple Regression analysis studies have found education to be a significant predictor of cognitive and functional status (Novack, Bush, Meythaler, & Canupp, 2001) as well as productivity (Sherer et al., 2002b) one-year after suffering moderate to severe TBI, with lower levels of education associated with poorer outcomes. Novak et al. (2001) in a study of 107 severely injured TBI patients found that premorbid factors, including education, had significant relationships with injury-severity, functional skills cognitive status and outcome. Studies of outcome following mild injuries also suggest that those with higher education levels have better outcomes than those who do not complete high school (Stulemeijer, Van Der Werf, Borm, & Vos, 2008).

Looking at the long-term (average 14 years) outcomes of TBI, Hoofien, Vakil, Gilboa, Donvick and Barak (2002) measured the predictive power of a number of variables, and found socio-economic status, one component of which was level of education, predicted long-term cognitive, psychiatric, vocational and social/familial functioning. Other studies have shown that those with higher status jobs return to work sooner than those with jobs which require lower levels of education, even though the high status jobs have more cognitive demands (Boake et al., 2005; Ruffolo, et al., 1999). Therefore it can be concluded that TBI patients with lower levels of education, particularly those who have not completed high school, have poorer cognitive and functional outcomes, and lower levels of return to work or productivity than those with more years of education.

3.1.4 Premorbid intelligence.

Because education has been shown to be correlated with intelligence (Neisser et al., 1996), studies linking lower levels of education with poorer outcomes post-TBI suggest that lower intellectual ability may also be a risk factor for worse outcomes. However there are very few studies which have directly examined pre-morbid intellectual functioning on outcome following TBI, possibly because the majority of studies of outcome are retrospective and use existing data bases which do not include this variable (Gordon, et al., 2006). To overcome this difficulty Vanderploeg, Curtis, Duchnick and Luis (2003) used standardised measures of verbal and arithmetic reasoning administered in a vocational setting to estimate premorbid intelligence quotient (IQ) in a sample of 626 individuals who had experienced a mild injury, and 3,896 who had not. This investigation found that participants with average levels of premorbid intelligence were two times more likely to be working full-time, than were those with lower than average premorbid intelligence.

Studies investigating the cognitive reserve hypothesis (Satz, 1993) suggest that smaller pre-morbid brain size may be a risk factor for poor cognitive outcomes following moderate to severe TBI (Bigler, Johnson, & Blatter, 1999; Kesler, Adams, Blasey, & Bigler, 2003) As there is a well-established correlation between brain size and intelligence in normal individuals (Wickett, Vernon, & Lee, 2000) this finding may also imply a relationship between intelligence and cognitive functioning following TBI.

3.1.4.1 Measures to estimate premorbid intellectual functioning.

National Adult Reading Test (NART; Nelson, 1982) is one of the most commonly used measures of estimated intelligence in English speaking patients with suspected intellectual deterioration. The test consists of a 50-item phonetically irregular word list which cannot be pronounced by common rules of pronunciation. The words are presented in order of increasing difficulty, and the participant reads them aloud. Error scores are used to estimate Wechsler Adult Intelligence Scale (WAIS III; Wechsler, 1996) Full Scale Intelligence Quotient (FSIQ) scores.

WAIS Vocabulary (WAIS Vocab.) is one of the subtests of the Wechsler IQ scales. David Wechsler proposed that this subtest was one of a number which were minimally affected by the effects of aging and brain-impairment (Wechsler, 1958) and it has been extensively used to estimate premorbid IQ (Lezak, Howieson, & Loring, 2004). The participant is asked to define 35 words presented in order of difficulty. A study by Crawford, Parker and Besson (1988) indicated that both the NART and the WAIS vocabulary are valid ways of estimating premorbid IQ in closed head injury patients.

3.2 Injury-related Variables

3.2.1 Injury-severity.

In moderate to severe TBI indicators of severity, such as length of loss of consciousness (LOC), depth of coma measured with the Glasgow Coma Scale (GCS; Jennett, Teasdale, & Braakman, 1976), and duration of post-traumatic amnesia (PTA) have been found to be predictive of psychosocial, cognitive and functional outcomes (Dikmen, Machamer, Winn, & Temkin, 1995a; Dikmen, Ross, Machamer, & Temkin, 1995b; Gordon, et al., 2006; Ownsworth & McKenna, 2004). A prospective study of Dikemen and colleagues (1995a), comparing 436 hospitalised head injured individuals and 121 general trauma control participants, found that the TBI group performed significantly worse on a range of neuropsychological measures, and the magnitude and the pervasiveness of impairments was dependent on injury-severity in a dose-response relationship. In this study injury-severity was measured by length of coma (time to follow commands) on the GCS. The group with <1 hour coma (n = 121) were comparable with the trauma controls, with no significant difference on any of the measures used (motor functioning, attention, executive functioning, memory and general intellectual abilities). Selective impairments on measures of attention and memory were found in the group with coma of more than 1 hour but less than 24 hours, and with further increase in injury-severity all measures were affected. However it is important to note that in this study there was variability in performance within severity levels. So although there was a dose-response relationship between severity and outcome, there was considerable overlap in outcome across severity groups. This finding suggests that there are no ranges of impairment that are specific to a TBI of a given severity, with the exception of extreme groups such as those with several weeks of coma.

Injury-severity has not been found to be a predictor of persisting PCS in mild injuries. The majority of mTBI patients return to normal occupational social and independent functioning within days or weeks following their injury (Alexander, 1995; Binder, Rohling, & Larrabee, 1997). However a small but significant minority continue to experience persistent cognitive, somatic and behavioural complaints usually referred to as post-concussion symptoms (PCS). While a large number of studies have attempted to identify reasons for this, injury-severity has not been implicated in the majority of them. For example a systematic review of the literature published between 1980 and 2002 on mTBI (Carroll, et al., 2004b) failed to find a study that reported severity of injury as an independent predictor of persistent PCS. Outcome studies have also indicated that disability is as common after mild injuries as after more serious ones (Thornhill et al., 2000; Whitnall, McMillan, Murray, & Teasdale, 2006).

3.2.1.1 Measures of injury-severity.

Loss of consciousness (LOC): A number of studies have found a relationship between loss of consciousness (LOC) and poor outcome (Cifu et al., 1997; Kreutzer et al., 2003) following TBI, and a longer period of coma has been shown to be associated with skull fracture and intracranial complication (Teasdale et al., 1990). However LOC may not always correlate with injury-severity. For example Hanlon, Demery, Martinovich and Kelly (1999) examined the roles of various acute neurological variables in relation to neuropsychological status and vocational outcome in 100 cases of mTBI, prospectively collected. They found no difference between patients who had suffered brief loss of consciousness and those without LOC. The use of LOC as a predictor of outcome also has some practical difficulties, in that individuals with mild injuries may not experience LOC, and those that do may not know its duration. For example, in a three-centre study approximately half of the sample was unable to report the duration of their LOC (Levin, et al., 1987). This may be further confounded in those who have consumed alcohol prior to their TBI, as the effects of alcohol may be indistinguishable from LOC.

Depth of coma: Depth of coma is usually measured with the Glasgow Coma Scale (GCS; Jennett, et al., 1976) an observational instrument consisting of three scales which evaluate and assign a numerical value to eye opening, verbal responses and motor response The GCS has a total score ranging from 3 to 15 and a convention has emerged (Jennett, 1998) that patients with a coma score of 8 or less are classed as severe, and those with a score of 13 or more as mild, with the others being classed as moderate.

Numerous studies have reported a significant relationship between depth of coma, as measured by the GCS and outcome. (Dikmen, et al., 1994; Wagner, Hammond, Sasser, Wiercisiewski, & Norton, 2000). However in mild injuries its utility has been questioned (Culotta, Sementilli, Gerold, & Watts, 1996), because the range of GCS scores from 13-15, by which mTBI is conventionally defined, encompasses a group which shows significant heterogeneity. Measurement of depth of coma using the GCS also has some practical limitations, particularly in mild injuries. It is a time-dependent assessment tool which must be administered quickly, as the symptoms it catches may resolve in hours. For example a GCS score of 10 at the scene of an accident, which would typically be classified as a moderate injury, may improve to 13, a mild injury, by the initial evaluation in the ED. Also in some injuries there may be unreliable responses in any one of the three areas that the scale assesses. For example facial swelling may restrict eye opening and drugs administered to reduce intracranial swelling may also affect responses. As GCS has to be measured at the time of injury its use is limited in studies where data is collected retrospectively, especially for mild injuries where a GCS score may not have been recorded, either in the field or in the ED.

Post traumatic amnesia (PTA): For hospitalised patients PTA may be measured prospectively using scales such as the Westmead Post Traumatic Amnesia Scale (Shores, Marosszeky, Sandanam, & Batchelor, 1986) and the Galveston Orientation and Amnesia Test (GOAT; Levin, O'Donnell, & Grossman, 1979). The GOAT assesses orientation to person, place, and time, and measures memory for events preceding and following the injury. A validity study of 52 closed head-injured patients found that the duration of impaired GOAT scores was strongly related to the acute neurosurgical ratings on the GCS (Levin, et al., 1979).

The Westmead Post Traumatic Amnesia Scale is a validated procedure for the measurement of PTA, containing twelve items assessing orientation and memory. The patient is asked seven questions, assessing orientation to time and place, and requested to remember the face and name of the assessor and three pictures of common objects. The next day the same questionnaire is repeated and the recall of face, name and pictures is checked using a standard procedure. This is repeated daily until a perfect score of 12 is recorded on three consecutive days, indicating that PTA has ended. A revised Westmead Post Traumatic Amnesia Scale (RWPTAS), designed to assess PTA on an hourly basis in mTBI patients in the ED, has also been developed and tested on 147 mTBI patients and 109 controls (RWPTAS; Ponsford et al., 2004). It was found to be a valid measure of PTA duration in adults for use in ED with mTBI**.** PTA may also be measured retrospectively using structured questionnaires, and these two methods of measuring PTA have been shown to be highly correlated (McMillan, Jongen, & Greenwood, 1996).

PTA duration has been shown to be predictive of long-term outcome. For example, a study of the predictive value of acute injury characteristics in mild to moderate head injuries (van der Naalt, van Zomeren, Sluiter, & Minderhoud, 1999) found that outcome and return to work were determined more by duration of PTA than by admission GCS. They also found that 100% of their patients with PTA shorter than 24 hours had a good outcome as measured on the Glasgow Outcome Scale (GOS; Jennett & Bond, 1975) at follow-up a year later. There is evidence that, in severe TBI, duration of PTA may contribute information that is dissociable from the duration of coma, and is related to the extent of multi-focal brain lesions. Wilson, Teasdale, Hadley, Wiedmann and Lang (1994) found that patients may have short or negligible coma, but prolonged PTA. They collected information for 38 TBI patients and found that a comparison of eight patients with periods of coma less than six hours, but with PTA greater than seven days, had significantly more extensive hemispheric damage compared with the rest of the group. Ellenberg, Levin and Saydari (1996) extended these findings in a sample of 314 severely-injured patients, by showing that PTA provides incremental information, apart from coma duration, in predicting outcome at six months post-injury. Fleming, Tooth, Hassell and Chan (1999) investigated predictors of community integration and vocational outcome two to five years after rehabilitation in a population of 449 individuals with severe TBI and PTA emerged as the most useful of the injury-severity indicators.

PTA therefore has a number of advantages over LOC and depth of coma as a measure of injury-severity: it has been shown to provide information dissociable from duration and depth of coma in severe injuries, it is better able to differentiate injuries in the mild range than GCS scores, and it can be measured retrospectively, enabling classification of injuries in which LOC is not known, did not occur and/or a GCS score was not recorded in the medical files.

3.2.2 Cause of injury.

Few studies have reported outcomes differentiated by cause of injury. The most consistent finding for those that do is that worse outcomes are experienced by those who are injured in violence-related TBI. For example Wendon et al. (1998b), in a large (n = 625) population-based study with injuries across the whole spectrum of TBI severity, found that outcome at six months was significantly worse for those who had been assaulted, as against all other causes of injury combined. Studies of longer term outcome using large numbers of participants have also found that those injured by violence-related TBI reported poorer outcomes. Gerhart, Millick and Weintraub (2003) reported poorer community integration and more PCS and disturbances of attention at one year post injury, while Hanks et al (2003) reported decreased productivity two years post-injury in individuals injured by violent means, compared to individuals injured by other causes. This latter study investigated the characteristics associated with violent TBI in a large sample (n = 1229) and found that this type of injury was more common in single men who were unemployed before their injury and had had a previous TBI. Other studies have found that those injured in a violence-related TBI are more likely to be single, unemployed males, with low education and a history of substance abuse (Bogner, Corrigan, Mysiw, Clinchot, & Fugate, 2001; Harrison-Felix et al., 1998).

One study of mild injuries (Hanlon, et al., 1999) found that TBI caused by an object striking the head, including assault and being struck by a falling object, was associated with greater disruption of cognitive functioning and poorer vocational outcomes than acceleration/deceleration injuries. Ownsworth and McKenna (2004) identify a few studies that have found that individuals with injuries of non-accidental or violent aetiology are less likely to return to work than accidental or non-violent injuries. Although the evidence is somewhat limited, it can be concluded that worse outcomes are experienced in those injured in violence-related TBI compared with injuries from other causes.

3.2.3 Previous TBI .

An early study by Gronwall and Wrightson (1975) demonstrated that speed of information processing was reduced more in young adults following a second TBI than in matched controls who had only had one head injury. Furthermore studies which exclude participants who have a history of a prior TBI have found significantly better outcomes, than studies that do not exclude them. For example Dikmen, McLean and Temkin (1986) compared 20 mildly injured individuals, with no previous head injury, on 21 neuropsychological measures, with 19 uninjured controls matched for age, education and gender. At one-month post injury significant differences were found on only two of the measures. This contrasts with results obtained by Barth Macciocchi and Giordani (1983) using comparable, and in some cases identical, measures in a sample of 71 patients who had sustained a TBI of comparable injury-severity, but 20% of whom had experienced a previous head injury. These researchers found that at three months 22 participants still demonstrated moderate to severe impairment on neuropsychological measures. Other studies have found that individuals who have persisting problems, particularly PCS, following mTBI are more likely to have experienced a previous head injury (Ponsford, et al., 2000; Thornhill, et al., 2000). However an early study (Ewing, McCarthy, Gronwall, & Wrightson, 1980) suggested that the persisting effects of a previous TBI may be subtle and only emerge under the effects of stress. In this study ten university students, who had recovered from minor head injury between one and three years previously, were given vigilance and memory tests at a simulated altitude of 3,800 metres. Their performance was significantly below that of a matched group of students who had never had a head injury.

A large body of research has looked at multiple concussions in sport. "Punch drunk" syndrome, a condition involving motor, cognitive and/or behavioural impairments in retired professional boxers, was described as early as 1929 (Martland & Beling, 1929). More recently well-designed studies using matched controls have found poorer performance on neuropsychological tests for players who have experienced multiple concussions in other contact sports such as American football (Collins et al., 1999) and soccer (Matser, Kessels, Jordan, Lezak, & Troost, 1998). When a second concussion occurs before the symptoms of an earlier TBI have cleared, a potentially fatal condition known as second-impact syndrome" has been described (Cantu, 1998).

A prospective cohort study (Guskiewicz et al., 2003) of 2905 football players from five US colleges, tested at preseason baseline on a variety of measures, and followed up prospectively, found an association between the reported number of previous concussions and likelihood of further concussions. Sixty-six (35.1%) of 188 injuries were recorded as "repeat injuries" from within the last seven years and players with a history of three or more previous concussions were three times more likely to sustain a concussion than those with no concussion history. Most (71.7%) concussions involved no LOC or PTA. Slow recovery time was also associated with a history of multiple concussions. The authors of this study suggest that increased risk of future injury and slower recovery may be due to increased physiological vulnerability, due to factors such as metabolic changes in the neurons and decreased cerebral blood flow post-injury.

From the research reviewed in this section, it can be concluded that a person with a history of TBI has an increased risk of incurring another one, and is likely to have greater cognitive impairment, and more PCS from subsequent TBIs. Furthermore recovery from a subsequent TBI is slower, and, if the subsequent injury occurs before the symptoms of the earlier TBI have cleared, the consequences can be fatal.

3.2.4 Hospitalisation.

The majority of TBI cases are not hospitalised: For example, a study of mTBI over a five-year period found only 16% of cases were treated in hospital (Fife, 1987). Other researchers have found incidence rates of 25% in mild to moderately injured samples (Sosin, Sniezek, & Thurman, 1996). Furthermore the majority of those who are admitted to hospital have only a short stay: data from Australia indicated that in 1997-1998 the majority (69%) of hospitalised cases were treated for no more than one day and only 11% are admitted for a week or more. The mean period of hospital stay following a TBI in Australia in that year was 4.6 days (O'Connor, 2002).

Hospitalisation following TBI may be due to the severity of the head injury or the severity of additional injuries. In the study by O'Connor, quoted above, the elderly were more prominent amongst cases with a length of stay of at least one week (26% compared with 8% of other cases). Moreover the elderly falls cases comprised only 16% of the falls cases with a short length of stay (a week or less) but made up 59% of the falls-cases with a long length of stay (more than a week). Research has shown that patients admitted to hospital with significant other injuries in addition to a TBI may not have the head injury diagnosed on admission (Moss, Powers, & Wade, 1996).

Most outcome studies following mild injuries (mTBI) involve patients who were hospitalised for other reasons following their injury or people with sporting injuries who did not require hospitalisation. Studies of ED presentations may include non-hospitalised cases but this information is not generally reported. In a systematic review of mTBI research (Carroll, et al., 2004b) 84 % of the 43 studies listed were of sporting injuries (n = 9) or hospitalised mTBI (n = 27), and only one study included information about numbers of hospitalised and not hospitalised participants. However in studies which do include non-hospitalised TBI patients, more PCS and poorer functional outcomes were experienced by those who had been admitted to hospital, and by those whose additional injuries were more severe (Lowdon, Briggs, & Cockin, 1989; Wenden, et al., 1998b). This may be the result of other-system injuries sustained in the same accident, which have been shown to impact negatively on outcome following TBI (Dikmen & Machamer, 1995; Dikmen, et al., 1986).

However hospitalisation itself may lead to poorer outcomes: when mTBI participants were randomly allocated to hospital admission for 24 hours or discharge from the ED, those who were admitted reported their symptoms lasted a longer time (Lowdon, et al., 1989). No specific advice was given to those discharged, other than to return if severe headache, nausea or vomiting occurred; those admitted to hospital were given reassurance regarding continuing symptoms. The results of this study suggest that hospital admission may increase the incidence and severity of symptoms following mTBI, possibly because those admitted to hospital perceived their injuries as more serious compared with those not admitted. A study of length of inpatient stay (Hawkins, Lewis, & Medeiros, 2005) has indicated that although functional independence may be worse at discharge for those with shorter periods of hospitalisation, at 12-months post-injury this difference was no longer evident and those with shorter periods of inpatient stay had better communication skills.

The studies of hospitalised TBI reviewed in this section indicate that although few prognostic studies of TBI include hospitalisation as a variable. Those which do, suggest that more PCS and poorer functional outcomes are experienced by individuals who are admitted to hospital, even if their injury is mild. Patients admitted to hospital with significant other injuries in addition to a head injury may not have the TBI diagnosed on admission.

3.3 Post-injury Variables

3.3.1 Post-concussion symptoms (PCS).

Post-concussion symptoms (PCS) are a constellation of physical, cognitive and emotional symptoms, which can occur in all severities of TBI (Gordon, et al., 2000). Those most commonly reported are headaches, fatigue, forgetfulness and sleep difficulties (Carroll, et al., 2004b). A number of questionnaires and symptom checklists have been developed to quantify the presence and duration of PCS following TBI: one of these, the Rivermead Post-Concussion Symptoms Questionnaire (RPQ; King, Crawford, Wenden, Moss, & Wade, 1995), is reviewed below. PCS have also been reported following other injuries, in chronic pain patients and in healthy controls, but they are more common in the first month after mild TIB than after other injuries or in the general population (Paniak, Phillips, Toller-Lobe, Durand, & Nagy, 1999). TBI patients with milder injuries are more likely to report higher levels of PCS than those with severe injuries (Gordon, et al., 2000; Whiteneck, Gerhart, & Cusick, 2004b).

Although PCS are largely resolved within 3 months in most people with mTBI (Carroll, et al., 2004b), a significant number of patients continue to report symptoms at six-months, and some are not symptom free at twelve months post-injury (Alves, Macciocchi, & Barth, 1993; Rutherford, et al., 1979). Higher levels of PCS shortly after injury have been related to poorer outcomes and persistent symptoms in mTBI (De Kruijk et al., 2002; Stulemeijer, et al., 2008). Persistent PCS are associated with psychosocial poor functioning (Dikmen, et al., 1989) and are predictors of poor outcomes for months or even years post-injury (Alexander, 1992). When PCS are persistent they are often referred to as post-concussion syndrome.

The problem of predicting those patients likely to experience persisting symptoms has been addressed by numerous studies, and emotional, neuropsychological and neurological factors have all been found to be important (King, 1996; King, Crawford, Wenden, Caldwell, & Wade, 1999; Ponsford, et al., 2000; Wood, 2004). Being able to predict who will develop persisting symptoms is important, in order to target interventions most appropriately, and attempts have been made to develop an assessment tool to differentiate those who are likely to develop them. King et al. found that emotional factors measured early after injury were the best predictors of PCS three months after TBI, and they suggest using a brief screening battery consisting of the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983), the Rivermead Post-Concussion Symptoms Questionnaire (RPQ; King, et al., 1995), assessment of PTA, a measure of divided attention (PASAT; Gronwall, 1977) and a short orientation and memory test (SOMAC; Katzman, Brown, & Fuld, 1983). More recently, researchers in Australia (Sheedy, Harvey, Faux, Geffen, & Shores, 2009) have developed a brief screen, consisting of immediate and delayed memory of five words and a visual analogue scale score of injury-related headache, to be used in the ED to predict those likely to suffer post-concussion syndrome. An initial trial with 100 mTBI patients found 80% sensitivity and 76% specificity for the prediction of clinically significant symptoms at three months post-injury. A cross validation study in Montreal, Canada (Faux, Sheedy, Delaney, & Riopelle, 2011) with 107 patients assessed in the ED following a mTBI and followed up by phone using the RPQ at three months post-injury found that immediate verbal recall and a quantitative recording of acute headache were able to predict post-concussion syndrome with a sensitivity of 70.2% and a specificity of 64.2%. This identification of "at risk" mTBI patients with a screen of this nature, if implemented widely through the use of appropriate protocols and guidelines in the EDs of acute hospitals, would greatly facilitate appropriate early intervention in mTBI.

3.3.1.1 Measures of PCS.

Rivermead Post-Concussion Symptoms Questionnaire (RPQ; King, et al., 1995) is a measure of the severity of PCS. It uses a five-point likert scale to measure the severity of 16 physical symptoms commonly seen following TBI. The participant is asked about change in their experience of symptoms by comparing themselves at the time of administration, to before their accident on each of the items. It has been shown to be a valid measure of the severity of PCS (Ingebrigtsen, Waterloo, Marup-Jensen, Attner, & Romner, 1998) with good test-retest reliability when used as a self-report measure (r = 0.91) and inter-rater-reliability when used as a questionnaire administered by two different clinicians (r = 0.87) (King, et al., 1995). A total score is obtained by summing item scores, and the range is 0 to 64. Potter, Leigh, Wade and Fleminger (2006) used the cumulative frequency RPQ scores in a sample of 168 TBI patients to suggest the following classification bands for use in clinical practice: 0—12 = minimal, 13—24 = mild, 25—32 = moderate and above 32 = severe levels of symptoms.

3.3.2 Depression.

Psychiatric problems, particularly depressive illnesses, have been found to be common following TBI (Fann, Katon, Uomoto, & Esselman, 1995; Silver, Kramer, Greenwald, & Weissman, 2001). This may be because individuals with mood disorders are more likely to have a TBI, or it may be that TBI causes depression in a percentage of patients. Jorge et al (2004) in a study of 91 TBI patients found that those who developed depression during the first year post-injury were more likely to have a history of mood and anxiety disorders. This suggests that that may have been more prone to develop psychiatric symptoms and major depression when exposed to significant stress. However there is also evidence that TBI causes depression. A review of the literature on the basis of causation criteria found that, although most studies have methodological limitations, there is strong evidence that TBI frequently causes some psychiatric disorders, including depression and anxiety (Van Reekum, Bolago, Finlayson, Garner, & Links, 1996).

A number of studies have found prevalence rates of depression in heterogeneous TBI around 40% (Jorge, Robinson, Starkstein, & Arndt, 1994; Kreutzer, Seel, & Gourley, 2001) with one study reporting rates as high as 77% (Varney, Martzke, & Roberts, 1987). Depression has also been reported following mild injuries. Although in one study (Alexander, 1992) higher rates were reported in mild than in more severe injuries, other studies report rates of less than 20% in mild injuries (Jorge, et al., 2004; Rapoport, McCullagh, Streiner, & Feinstein, 2003).

The study by Varney and colleagues (1987) is notable because it is one of the few early studies that used Diagnostic and Statistical Manual of Mental Disorders (DSM-III; American Psychiatric Association, 1980) criteria to assess depression, and also because it included a control group of patients with back injuries. Seventy seven percent of head injured patients met DSM-III criteria for a diagnosis of major depressive disorder compared to 38% of controls. Almost half (46%) of the head injured patients reported that their symptoms of depression did not begin until six months post injury. One third of the depressed group did not appear depressed during the interview, and only 18% spontaneously complained of depressive symptoms. Despite the fact that more than half of the depressed patients reported crying spells and/or suicidal ideation, only 21% had sought psychiatric or psychological care prior to interview. This finding points to the importance of including questions about mood in rehabilitation assessments. This is particularly pertinent in multidisciplinary settings, because although the co-existence of depression and other medical conditions is well recognised, research suggests that many health professionals fail to recognise it. For example, Pignone et al. (2002) reported that primary care physicians failed to diagnose 35% to 50% of patients with depression. A study evaluating the accuracy with which physiotherapists screen for depressive symptoms in patients with low back pain in private physiotherapy clinics in the Australian city of Sydney, found that their ability to accurately detect depression was significantly improved by the inclusion of a two-item screen for depressive symptoms (Haggman, Maher, & Refshauge, 2004).

Using a large sample (*n*=722) Kreutzer et al. (2001) found 42% of the sample met the DSM-IV (American Psychiatric Association, 1994) diagnosis for major depression, on average more than two years post-injury. However participants comprised patients who were referred for outpatient assessment and it may be that they contained a large proportion of those who were experiencing difficulties, and are not therefore representative of the whole TBI population. In contrast, a well-designed study by Deb, Lyons, Koutzoukis, Ali and McCarthy (1999) used hospital records to identify all hospitalised patients, over a one-year period, who were diagnosed as having a TBI according to the ICD-9 codes, and who met specific criteria for TBI. Face-to-face interviews were then used to identify the presence of psychiatric disorders and it was found that a depressive illness was present in 13.9% of patients.

There is a body of evidence suggesting that depression may frequently be a long-term problem following TBI. For example Hibbard, Uysal, Kepler, Bogdany, and Silver (1998) used a structured interview and DSM-IV criteria for 100 TBI adults, on average eight years post-injury, and found a prevalence of Major Depression of 61%. An association between a history of TBI and an increased lifetime prevalence of major depression has also been found in a study of World War II veterans. Veterans with a history of TBI were more likely to report major depression in subsequent years, and were more often currently depressed; suggesting the risk of depression is elevated for decades following head injury. This lifetime risk of depression also increased with injury-severity (Holsinger et al., 2002).

Depression is associated with poorer outcomes following TBI of all severities: in a study by Levin et al (2001), a major depressive episode following TBI was associated with increased levels of anxiety, cognitive deficits and disability in mild to moderate injuries, relative to patients who did not develop depression. In another study (Jorge, et al., 2004) of 91 patients with TBI severities from mild (44%) to severe (23%), those who had a major depressive episode at the time of evaluation had lower scores on tests of memory and executive functioning, compared with controls who had experienced multiple trauma without any injury to the brain. A major depressive episode lasting more than six months has been associated with deterioration of social functioning and activities of daily living during the one-year period after TBI (Fann, et al., 1995; Gomez-Hernandez, Max, Kosier, Paradiso, & Robinson, 1997; Jorge, et al., 1994).

In summary depression is a common problem following TBI and may be present premorbidly or be caused by the TBI itself. Prevalence rates vary across studies, from less than 20% in mild injuries to as high as 77% in heterogeneous TBI. Because depression is associated with poorer cognitive, psychosocial and functional outcomes in TBI of all severities it is important to diagnose and treat it. However, research has indicated that if depressed TBI patients are not asked directly about symptoms of depression they may not be detected, pointing to the importance of including questions about mood in rehabilitation assessments.

3.3.3 Anxiety.

Anxiety disorders are common in the general population and may be even more common in people with TBI. Anxiety in general has been reported at rates as high as 70% following TBI (Rao & Lyketsos, 2002). However, although many reports cite that anxiety symptoms commonly accompany TBI, rigorous diagnosis is frequently absent. In rehabilitation settings symptoms of anxiety are often overlooked or assumed to be a normal reaction to trauma.

A meta-analysis of 12 studies comprising 1199 total participants, revealed an overall prevalence of anxiety disorders of 29% across all severities of TBI (Epstein & Ursano, 1994 cited in ; Moore, Terryberry-Spohr, & Hope, 2006). There are few prospective studies of unselected samples, but one prospective study was undertaken in Wales by Deb et al. (1999) to evaluate the type and extent of psychiatric syndromes in patients with TBI. As described in the section above, hospital records were used to identify all patients with a diagnosis of brain injury, according to the ICD-9 codes, and who met specific criteria for TBI. Face-to-face interviews and questionnaires were then used to establish diagnoses. A subset of all patients aged 18—64 years (n = 164) was compared with figures from the UK Office of Population Censuses and Survey Study

(Meltzer, Gill, Petticrew, & Hinds, 1995), and results indicated that 9 % of the TBI patients had Panic Disorder compared with 0.8% in the general population. Other diagnoses had figures which were more comparable to the general population (2.5% of TBI patients compared with 3.1 of general population for Generalised anxiety disorder, and 1.6% of TBI patients compared with 1.2% of general population for obsessive compulsive disorder). Two thirds of the 30 patients with a psychiatric diagnosis had multiple diagnoses.

There are few studies investigating outcome in TBI patients with comorbid anxiety disorders, but, in general, when compared with TBI patients without anxiety or depression, anxious TBI patients are more functionally disabled and perceive their injury and level of cognitive impairment to be more severe than is objectively evident. A study by Fann, Katon et al. (1995) also found that anxiety disorders were associated with an increase in reporting of somatic symptoms, such as headache, dizziness and blurred vision.

Depression and anxiety have a high rate of co-morbidity in the general population and there is evidence that co-morbidity may be higher following TBI (Jorge, et al., 2004). In mild injuries, measures of anxiety and depression taken shortly after injury have been shown to be predictive of persistent PCS (King, 1996; Mooney & Speed, 2001). Mooney and Speed in a study of 80 mTBI patients (Mooney & Speed, 2001) found that two thirds of those with a comorbid psychiatric diagnosis, primarily depression and/or anxiety, had prolonged and complicated recoveries, as opposed to the majority of those without psychiatric issues. There are also data that indicate that the psychiatric results of a mTBI remain many years post-injury, interact with PCS and do not mitigate in the absence of treatment (Bornstein, Miller, & Van Schoor, 1989).

In summary symptoms of anxiety are common following TBI but are often overlooked or assumed to be a normal reaction to trauma. Rigorous diagnosis is therefore often absent, although treatment of anxiety following TBI is important because TBI patients with anxiety are more functionally and cognitively disabled and report more PCS. Depression and anxiety have high rates of co-morbidity following TBI.

3.3.3.1 Measures of mood.

Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983) is a self-assessment scale, developed as a screening tool for use in general medical settings, which consists of two subscales, measuring anxiety and depression. It was designed to exclude symptoms that may arise from the somatic aspects of illness, such as insomnia and fatigue. The HADS has been validated (Bjelland, Dahl, Haug, & Neckelmann, 2002) in healthy, psychiatric and neurological populations including those with TBI (Whelan-Goodinson, Ponsford, & Schönberger, 2009) and has been extensively used in both hospital and community settings. It contains 14 items, rating seven symptoms of anxiety and seven symptoms of depression. The participant rates each item, based on how they have been feeling in the last week, on a four-point Likert scale (0 to 3). Suggested interpretation of scores are 0 to 7 = normal, 8 to 10 = mild, 11 to 14 = moderate and 15 to 21 = severe symptoms of anxiety or depression.

3.3.4 Disability and functional independence.

TBI can produce a range of neurological impairments which affect functioning across the physical, cognitive and psychosocial domains. Physical impairments predominate in the initial stages after TBI, particularly in severe injuries (Oddy, Humphrey, & Uttley, 1978), It is also important to note that, in addition to physical impairments caused by the brain injury, there may also be other physical problems, such as comorbid orthopaedic injuries which impair functioning in the initial stages. However, for injuries of all severities, psychosocial problems due to cognitive and behavioural problems often cause the most profound and long lasting difficulties (Ponsford, et al., 1995; Weddell, Oddy, & Jenkins, 1980). Attempts to assess functional status need to take account of this heterogeneity of possible dysfunctions. However measures of activities of daily living are often limited in scope to physical issues and do not address cognitive, communicative and psychosocial function, while neuropsychological measures have been criticised as being unrelated to real life functioning (Ponsford & Kinsella, 1992). Recognition of these limitations has led to the development of more global outcome measures, such as the Functional Independence Measure (FIM; Corrigan, Smith-Knapp, & Granger, 1997) and Disability Rating Scale (DRS; Rappaport, Hall, Hopkins, Belleza, & Cope, 1982) which are described below (Hall, Hamilton, Gordon, & Zasler, 1993).

3.3.4.1 Measures of functioning and disability.

Functional Independence Measure (FIM; Corrigan, et al., 1997) is a well-researched measure of functional independence, with demonstrated inter-rater reliability (r = .94) and test/retest reliability (r = .93) (Ottenbacher, Hsu, Granger, & Fiedler, 1996). It has demonstrated reliability for use in TBI rehabilitation: a study of 95 TBI patients (Corrigan, et al., 1997) found the FIM to be highly predictive of minutes of assistance (83% accuracy), supervision (82% accuracy) and the need for either type of assistance (78% accuracy).

The FIM comprises 18 items which address self-care and motor functions, and five items that measure cognitive functions, and is designed to grade functional abilities or disabilities based on observation of behaviour. It is scored according to the relative dependence of the subject upon others: each item is rated on a scale ranging from one (total assistance) to seven (complete independence). A maximum score of 126 indicates complete independence on all items. A Rasch Analysis by Linacre et al. (1994) identified two separate statistically and clinically different indicators: disability in motor functions (13 items) and disability in cognitive functions (5 items). In inpatient settings observation by a multidisciplinary team over a 72-hour period is recommended for collecting data for the FIM. However in outpatient settings, this may change to self-report, either in person or over the telephone, one-off observations, or reports from carers. There is good intermodal agreement between in person and telephone methods of data collection (Smith, Illig, Fielder, Hamilton, & Ottenbacher, 1996).

Scores on the FIM at discharge from acute rehabilitation have been shown to predict outcomes, such as need for rehabilitation services (High Jr et al., 1996) return to work (Greenspan, et al., 1996) and quality of life (Webb, Wrigley, Yoels, & Fine, 1995).

Disability Rating Scale (DRS; Rappaport, et al., 1982) is a measure used for assessing disability over the course of TBI recovery. It consists of eight items divided into four categories. The maximum score an individual can obtain on the DRS is 29 (extreme vegetative state). A person without disability will score zero. The DRS has been proven reliable and valid (Gouvier, Blanton, LaPorte, & Nepomuceno, 1987; Hall, et al., 1993; Hammond et al., 2001) and more sensitive to changes than the Glasgow Outcome Scale (GOS; Jennett & Bond, 1975). In a comparison with the Glasgow Outcome Scale 71% of TBI individuals showed improvement on the DRS but only 33% on the GOS (Hall, Cope, & Rappaport, 1985). The DRS can be self-administered or scored through an interview with the patient or a family member and is quick and easy to score. An additional advantage is the ease and brevity with which information can be obtained by phone interview. Although not optimum, DRS ratings can even be obtained by medical record review retrospectively in certain cases. DRS scores at rehabilitation admission and discharge have been shown to be predictive of return to work (Ponsford, et al., 1995). However a limitation of the DRS is that it was developed to measure disability in severe TBI (Rappaport, et al., 1982) and may not be appropriate for measuring outcome in milder injuries. It has been shown to be unable to reflect subtle but sometimes significant changes in individuals, within a specific, limited window of recovery (Hammond et al., 2004).

In summary, TBI can produce a range of impairments affecting functioning across physical, cognitive and psychosocial domains and attempts to assess functional status need to take account of this heterogeneity of possible dysfunctions. Measures of functional dependence and disability have been shown to predict outcomes, such as need for rehabilitation services, ability to return to work and quality of life.

3.3.5 Cognition.

The cognitive sequelae of TBI have been extensively studied, and although the methods used to measure different cognitive functions differ widely between studies, there is strong evidence to suggest that neuropsychological measures are predictive of outcome after TBI. Schretlen and Shapiro (2003) conducted a meta-analysis of 39 studies of the cognitive effects of mild and moderated-severe TBI, from the acute phase to long-term follow-up (> 2 years post-injury). These researchers conclude that, overall, cognitive functioning recovers most rapidly during the first few weeks following mTBI and returns to baseline one to three months post injury. In moderate-severe TBI, although there is improvement over time, patients tested more than two years post-injury continue to show marked impairment. They also found that moderate-severe TBI causes larger and more persistent impairment of overall cognitive functioning compared to mTBI.

Several studies (Boake et al., 2001; Sherer et al., 2002a; Sherer, et al., 2002b) have found that early neuropsychological assessment is predictive of employment and productivity outcomes. For example Sherer et al. (2002b) examined the relationship between early cognitive status and productivity one year after injury in 388 adults with TBI. Multiple logistic regression analysis revealed that pre-injury productivity status, duration of PTA, education level and early cognitive status each made significant independent contributions to the prediction of productivity status at follow-up. When adjusted for all other predictors, persons scoring at the 75^{th} percentile on measures of early cognitive status had 1.61 times greater odds of being productive at follow-up than those scoring at the 25^{th} percentile. The most reliable indicators of return to work in both the Crepau and Scherzer (1993) and the Ownsworth and McKenna (2004) reviews of factors related to employment outcome were measures of executive functioning.

A review of memory impairment in moderate to severe TBI (Vakil, 2005) found that, although memory impairment in TBI patients affects many aspects of memory, it can be viewed, at least to some degree, as a consequence of a more general cognitive deficit. The most vulnerable memory processes following TBI resemble memory deficits reported following frontal lobe damage. Several studies have investigated working memory in TBI patients using Digit Span and it has been suggested that digits forwards represents memory span (or the phonological loop in Badeley's model), and digits backwards requires the manipulation of information in short-term memory—the central executive in Badeley's model (Baddeley & Hitch, 1974; Haut, Petros, Frank, & Lamberty, 1990). Several studies have found that while digit span forward is intact, digit span backward is impaired in patients after TBI (Brooks, 1975; Haut, et al., 1990).

3.3.5.1 Measures of cognitive functioning.

Controlled Oral Word Association Test (COWAT), also known as FAS, is a measure of verbal fluency, measured by an individual's ability to generate words beginning with a specific letter. Standardised norms are available and the COWAT has been shown to be sensitive to the effect of brain injuries (Spreen & Strauss, 1998).

Trail Making Test is frequently included in neuropsychological test batteries as a measure of executive function (Tombaugh, 2004). It has two parts Test A and Test B. Test A involves drawing lines sequentially connecting 25 encircled numbers distributed on a sheet of paper, whereas Test B requires the participant to connect numbers and letters alternately. Scoring for both tests is the number of seconds taken to complete each trial, with lower scores representing better performance (Strauss, Sherman, & Spreen, 2006). The Trail Making Test has been found to have adequate test-retest reliability (r = .86) (Goldstein & Watson, 1989) and to be sensitive to the effect of brain injury (Strauss, et al., 2006).

Information Processing Task is one of the subtests in the Adult Memory and Information Processing Battery (AMIPB; Coughlan & Hollows, 1985). The test consists of 105 rows of five numbers. The participant is asked to cross out the second highest number of in each row and complete as many rows as possible in four minutes. The task is designed to have as little demand as possible on memory and general intelligence, and an adjustment for motor speed is provided. A parallel version of the test is provided and each version has been standardised on a separate pool of approximately 180 subjects, evenly distributed over four age groups ranging from 18 to 75 with test-retest correlations for the two forms of the task of .79 and .89. The Information Processing Task has been shown to be sensitive to the effects of neurological injury (Coughlan & Hollows, 1985).

Digit Span is a subtest of the Wechsler Adult Intelligence Scale (WAIS III; Wechsler, 1996) and is a measure of working memory. Norms are available based on the WAIS III standardisation project.

Digits Forward minus Backward: Differences between the digits forward and digits backwards task of the Digit Span subtest of the WAIS-R (Wechsler, 1981) have been found to be large in brain-damaged patients, compared to normal controls (Banken, 1985). For example in a sample of 52 adults with mild to moderate TBI, 25 could reverse no more than four digits, and were therefore in the below-average range for this test but 41 had digit forward spans in the average range, i.e. from six to nine. Using a measure of the discrepancy between the two tasks, obtained by subtracting the raw string length for Digits Backward from the raw string length for Digits Forward, information is captured which is lost when the scores are combined to produce the Digit Span sub-test of the Wechsler Intelligence Scales (Lezak, et al., 2004)

3.4 Summary

In summary, many factors have been shown to influence outcome following TBI. In the demographic domain age-at-injury and education are the most significant variables: age has been shown to be an independent predictor of outcome following TBI of all severities, with older people experiencing poorer psychosocial, cognitive, functional and employment outcomes, while TBI patients with lower levels of education, particularly those who have not completed high school, have lower levels of return to work and productivity (work/study/full-time home-making) than those with higher levels of education. Lower premorbid IQ, may also be a risk factor for poorer outcomes following TB of all severities. Few studies report outcome following TBI by gender, but the available research suggests that some outcomes, particularly reporting of post-concussive symptoms, may be worse in women than men. However further research in this area is needed.

In moderate and severe injuries, the severity of the injury is the most important of the injury-related predictors of outcome, but severity has not been shown to be a predictor of poor outcome in mild injuries. Individuals who are injured in a violence-related TBI have been shown to experience more PCS and greater disruption of cognitive functioning, than those injured by other causes. Few prognostic studies of TBI include hospitalisation as a variable. Those which do, suggest that more PCS and poorer functional outcomes are experienced by individuals who are admitted to hospital, even if their injury is mild. Patients admitted to hospital with significant other injuries in addition to a head injury may not have the TBI diagnosed on admission. A history of TBI has been shown to be related to greater cognitive impairment, more PCS and an increased risk of incurring another TBI.

Poorer outcome and persisting symptoms have been associated with higher levels of PCS reporting post-injury. Psychiatric problems, particularly depression, are common following TBI, and are associated with poorer outcomes for injuries of all severities. Symptoms of anxiety are also common, but anxiety is often overlooked or assumed to be a normal reaction to trauma. Psychiatric symptoms following TBI may be due to premorbid problems or a direct result of the injury. Research has indicated that if depressed TBI patients are not asked directly about their symptoms, the depression may not be detected, pointing to the importance of including questions about mood in rehabilitation assessments. Functional dependence may be due to physical or cognitive and psychological difficulties, with physical difficulties predominating initially, but cognitive and behavioural problems becoming increasing prominent over time. Measures of functional dependence and disability have been shown to predict outcomes, such as the need for rehabilitation services, the ability to return to work and quality of life. Cognitive functioning has been shown to be a strong predictor of employment and productivity. The most reliable cognitive indicators of return to work are measures of executive functioning.

This chapter has summarised some of the most important prognostic variables following TBI. Identification and understanding of these variables provide the important basis on which to guide and examine rehabilitation following TBI, and will be important factors in developing a model of rehabilitation pathways. The research summarised suggests that those at risk of poor outcomes, and therefore more in need of rehabilitation interventions, are TBI patients with one or more of the following characteristics:

- older (> 60 years of age);
- have fewer years of education (for example, not completed high school);
- have lower IQ;
- be female;
- have had a previous TBI;
- report more PCS;
- have psychiatric symptoms pre- and, or, post-injury;
- have higher levels of disability post injury;
- have lower levels of functional independence post-injury;
- have more-severe injuries.

A proportion of those with mild injuries are also at risk for poor outcomes. This may be due to the presence of some of the variables outlined above, but it will be important in developing a model of rehabilitation pathways to include those with mTBI.

Chapter 4 will give an historical overview of the development of rehabilitation interventions for TBI and outline current trends, in order to identify limitations in previous research, and provide a rationale for the focus of the studies described in this thesis.

CHAPTER 4 - Traumatic Brain Injury Rehabilitation

4.1 History of Rehabilitation for TBI

The earliest approaches to rehabilitation of brain injury were made in response to the large numbers of people who suffered these types of injuries in World War I (Boake & Diller, 2005). In Germany special military hospitals for the treatment of brain injuries were set up in Cologne in 1914 by Walter Poppelreuter, and later in Frankfurt, Mannheim and Munich (Poser, Kohler, & Schönle, 1996).

These early attempts at TBI rehabilitation drew on the work of Pierre Paul Broca and Carl Wernicke, and one of their aims was to "map" these brain functions. The other aim was to find ways to assess and treat disabilities. There was no previous experience in rehabilitation, so initially different approaches were tried and modified in the light of experience. Despite this ad hoc approach, some of the major innovations in the field of rehabilitation stem from this time. For example, Poppelreuter emphasised the importance of an inter-disciplinary approach and the necessity for systematic assessment, while the significance of the brain-damaged individual's insight into his own disabilities, which is still important in rehabilitation research today, was also a focus of this early work.

In the years between World Wars One and Two, the field of rehabilitation was dominated by the work of Kurt Goldstein, who built on earlier work, but also developed fundamentally new ideas and criticised some previous theoretical and practical approaches (Goldstein, 1918; Godlstein & Gelb, 1920, as cited in Poser, et al., 1996). Without casting doubt on the fact that simple physiological functions, such as touch and sight, are located in clearly defined areas of the brain, Goldstein assumed co-operation between different brain areas. The problem of whether it is better to improve preserved abilities (a restorative therapy), or to practice compensation strategies (a compensatory therapy) was solved in a pragmatic way. If only some functions were damaged it was assumed that these could be taken over by other areas, and the emphasis was on practice and retraining. However if more pronounced lesions were present, the emphasis was on compensatory approaches.

The primary outcome measure for all of these early rehabilitation efforts was employment. It was increasingly realised that many patients suffered from the late after-effects of the trauma and up to 50% suffered epileptic seizures. Simple kinds of occupation such as weaving, pottery, basket-making and gardening were increasingly taught and occupational therapy became an integral part of the treatment regime. After the national socialists took over in Germany, therapy included gymnastics, team games and body building activities. These early attempts at physical therapy were used to train the ability to react, concentrate and focus attention, while it was also believed that they reduced psychological problems.

Specialised centres in the UK, the Soviet Union and other countries were developed in the post-war years. The work of Goldstein in Germany had been disturbed by the Holocaust, during which he fled to USA where he published an updated review of TBI rehabilitation in English (Goldstein, 1942). The Russian neuropsychologist, Alexander Luria, developed a model of rehabilitation, in which diagnosis and treatment are intrinsically related, and both intact and disturbed functioning are taken into account. This model incorporated four principles (Christensen & Caetano, 1996): respect for the uniqueness of the individual; use of intact functions to compensate for damaged ones; externalisation of previously internalised acts through speech and other external aids; and the use of feedback to enable patients to identify and correct mistakes.

In the 1960s Russell and Smith (1961b) developed a system for measuring post-traumatic amnesia, and showed it to be a predictor of return to work. Follow-up studies described the prevalence and risk of post-traumatic epilepsy (Russell, 1968) and other complications. The English publication of Goldstein's work influenced studies of aphasia in Edinburgh by Edna Butfield and Oliver Zangwill (Butfield & Zangwill, 1946) using pre- and post-treatment designs, and similar studies were carried out in California by Joseph Wepman (1951), who measured outcome using standardised psychological tests.

The rapid growth in high-speed travel in the 1970s saw a commensurate increase in the rate of TBI from motor vehicle accidents. Neurosurgeons, concerned about the outcome of their patients, initiated a series of outcome studies (Jennett & MacMillan, 1981) and the Glasgow Coma Scale (GCS) and the Glasgow Outcome Scale (GOS) were developed (Jennett, 1976; Jennett & Bond, 1975), to better quantify injury-severity and outcome.

4.1.1 Holistic cognitive rehabilitation.

Following the Yom-Kippur War of 1973 in Israel, Yehuda Ben-Yishay, who had studied under Kurt Goldstein in the late 1950s, had an opportunity to develop the first holistic program for brain-injured soldiers. He observed that the residual cognitive, emotional and behavioural sequelae of head injury greatly exceed the physical, as a cause of difficulties in long-term vocational rehabilitation (Ben-Yishay, Silver, Piasetsky, & Rattok, 1987). A number of studies (Bond, 1975; Bruckner & Randle, 1972; Weddell, et al., 1980) had indicated that TBI patients with greater memory, learning and personality deficits had poorer work adjustments, than those with similar degrees of injury-severity but fewer deficits in those areas. Other problems, such as social isolation, spontaneity and a tendency to fatigue were barriers to return to premorbid occupations in a number of other studies (Barth, et al., 1983; Prigatano, Fordyce, & Zeiner, 1984).

In order to respond to these observations, Ben-Yishay developed a holistic (cognitive, interpersonal and vocational) neuropsychological rehabilitation outpatient program for young TBI patients who had failed to benefit from conventional rehabilitation approaches (Ben-Yishay & Diller, 1981; Ben-Yishay, et al., 1987). This program comprised three phases: the first phase was devoted to a 20-week intensive and systematic holistic individual and group remedial intervention, to ameliorate cognitive deficits in basic attention, finger dexterity, constructional praxis, visual-spatial information processing and verbal logical reasoning. A small-group procedure was designed to improve interpersonal communication, social competence, awareness and acceptance of the consequences of the head injury. The second phase was devoted to guided occupational trials, with a detailed and explicit treatment plan for each patient, based on the findings from the first phase. Occupational trials were conducted in actual work situations (offices, shops, libraries, services etc) under the guidance and supervision of a vocational counsellor. Work competence, level of productivity and the interpersonal appropriateness of the patients were judged jointly by the vocational counsellor and the actual supervisor at the work place. Participants were given an "employability" rating which was used in the third phase of the study to find work commensurate with their proven ability. Follow-up in this third phase was designed to assist participants to make initial adjustments to the new work environment. Discharge procedures included the establishment of a close liaison with the new employer, and with the local private or community services, agency-based mental health workers and/or vocational guidance practitioners, who provided the maintenance support service to the patient once he or she was back in the community.

The program was initially tested with 94 TBI patients, with an average age of 27 years. All but two were at least 12 months post-injury, when they began the program and, all were deemed unemployable, or unable to pursue academic studies, in any capacity. At the completion of the program, 84% were found to have attained the ability to engage in productive endeavours, 63% at a competitive level and 21% in a subsidized capacity; 16% were rated as unemployable/unproductive in any capacity. Over the three-year follow-up period, the percentage of patients who were rated as unemployable did increase, with decrements in employability being related to three factors: social isolation coupled with the absence of adequate maintenance and support systems, forgetting to consistently apply the rehabilitation strategies they had been taught, and financial disincentives to work.

Evaluating the results of this program, it was noted that participation yielded statistically significant improvement on a majority of measures in the areas of neuropsychological functioning, interpersonal and social skills and daily-life functional competence. However the magnitude of the improvements was modest. The authors concluded that the principal sources of the successful vocational outcomes were improvements in self-awareness, acceptance of the consequences of the injury and increase in the effectiveness of functional application of the residual information processing abilities (rather than an increment in the capacity levels per se). The basic model of Ben-Yishay's program has been emulated in many countries (Holsinger, et al., 2002; Prigatano, et al., 1984; Scherzer, 1986) and there is substantial evidence to support its effectiveness (Cicerone et al., 2000).

4.2 Mild TBI

Despite the fact that approximately 80% of TBIs are mild (Cassidy, et al., 2004b), little attention was paid to mild TBI (mTBI) until the 1980s (Ruff, 2005), when a number of papers documented the fact that, in a percentage of cases, long-term sequelae of the injury prevented return to work (Barth, et al., 1983; Rimel, Giordani, & Barth, 1981). Because many of the patients with persisting symptoms in these studies were seeking follow-up services, questions arose about whether or not they were representative of all mild injuries. In response to these questions, Levin, Mattis and Ruff (1987) undertook a prospective study of 57 mTBI patients (LOC of 20 minutes or less, GCS score of 13 to 15, no focal neurological deficits, no complications on CT scan and no history of neurological disorder, previous TBI, sustained alcohol or drug use and no hospitalisation for a psychiatric disorder) and 56 healthy controls, matched according to age, education, race and socio-economic background. These two groups were followed-up at one and three months post-injury. The conclusion that these authors came to was that "a single uncomplicated minor head injury rarely produces chronic disability or permanent cognitive impairment " (Levin, et al., 1987, p. 242).

Experimental studies in humans and animals in the late 80s confirmed findings from earlier studies of mTBI patients who died of other causes, that diffuse microscopic axonal injuries were associated with mTBI (Oppenheimer, 1968). This evidence supported the hypothesis that microscopic brain damage can result from even a mild injury, and the inference that this is the cause of ongoing PCS. Over time this idea was challenged by those who maintain psychopathology, and not neuropathology, to be the primary cause of ongoing symptoms, and two conflicting schools of thought emerged (Ruff, 2005), with debate continuing to the present time. However clinical consensus suggests that functional disability after mTBI is a result of multiple factors which needed to be identified in order for appropriate rehabilitation interventions to be designed and implemented. Kay et al. (1992) have proposed a model (see figure 4.1) for understanding functional disability after mTBI.

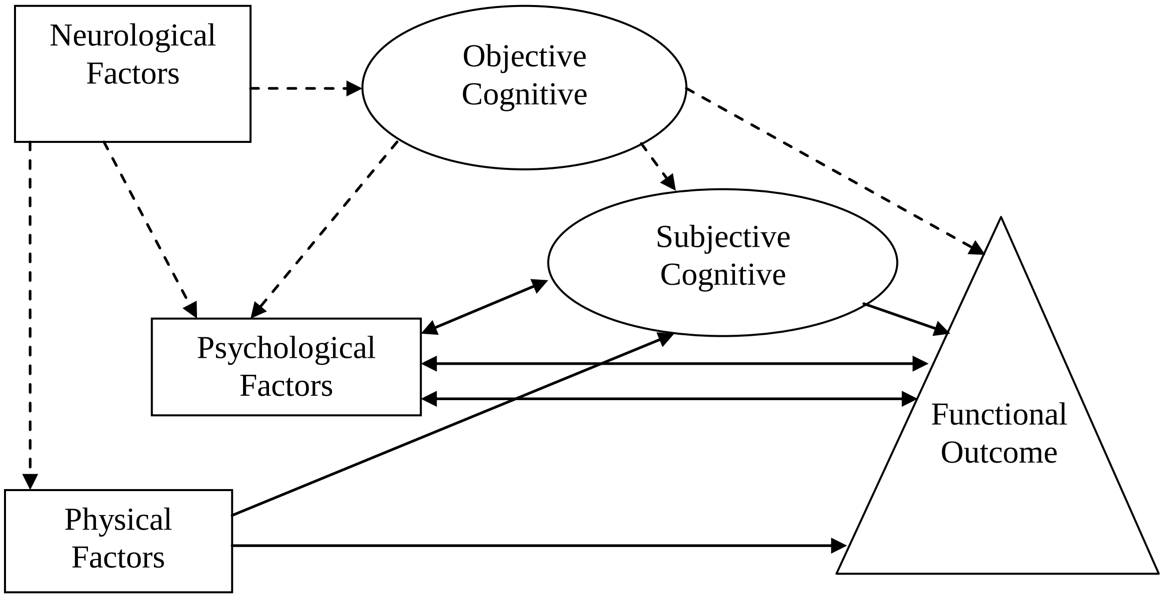


Figure 4.1 Neuropsychological Model of Mild Traumatic Brain Injury (Kay, et al., 1992)

The model contains the following three factors, represented by boxes on the left:

Physical Factors related to the TBI, co-morbid injuries and/or treatment that can directly affect the ability to function. For example pain, fatigue, sleep problems, sensory deficits or hypersensitivity, balance problems and effects of medication.

Psychological Factors are internal structures or responses that affect the ability to function. These can include personality style, affective status (especially anxiety and depression), sense of self, degree of psychological overlay, psychosocial situation (friends, family, job), and response to or motivations for being in litigation.

Neurological Factors include both pre-existing factors such as age, brain integrity and previous damage to the brain, and injury-related factors, which includes both structural damage and also non-structural damage such as neurotransmitter changes. In combination, these factors determine the extent of damage to the brain, and whether the effects are temporary or permanent.

An important aspect of the model is the distinction between objective cognitive deficits and subjective cognitive deficits, each represented by an oval. Objective cognitive deficits are those primary cognitive changes determined directly by damage to the brain. The subjective cognitive deficits are the breakdowns in mental processing experienced by the injured-person and manifested on neuropsychological testing. These can be caused not only by objective cognitive deficits due to the brain injury, but by psychological and physical factors as well.

The dotted lines in the model indicate paths of influence that may weaken and even disappear with time. This can result in functional disability that continues, even after the disappearance of the objective factors that set the system in motion.

The three factors interact in complex ways, as indicated by the lines and arrows in the model. For example, a patient may complain of being unable to concentrate and show neuropsychological deficits on a number of tests of attention. The model suggests two possibilities. In one case neurological damage may be directly causing primary cognitive deficits that directly impact functioning. Under a second scenario, objective cognitive impairment is quite minimal, but, because of psychological factors, the presence of even mild distractibility causes enormous anxiety and fear, resulting in a strong flow from the psychological factor into the subjective cognitive factor. In the first case, the link between objective cognitive factors and functional outcome carries the greatest weight of influence; in the second, the connection between psychological factors and subjective cognitive causes the greatest impact on functional outcome. In these two cases the implications for intervention are profoundly different: in case one a cognitive remedial intervention would be appropriate, while in the second case an intervention to reduce anxiety would be indicated.

The authors of this model outline its implications for treatment and set out clinical guidelines for both early preventative therapy, and late interventions in patients who present for rehabilitation, months or even years post-injury. The model has been validated empirically in both adults (Paniak, Toller-Lobe, Reynolds, Melnyk, & Nagy, 2000; Ponsford et al., 2002) and children (Ponsford et al., 2001).

4.2.1 Mild TBI diagnosis.

Diagnosing mTBI is particularly challenging because many patients do not have any contact with hospital services and may not even present to their local physician until days or even weeks post-trauma. To diagnose mTBI retrospectively, it is essential to establish if a memory gap exists. This gap in memory may be caused by LOC, PTA or a combination of both, but it must result from an external force to the brain, and not from other causes such as drug use or psychological trauma.

In 1993 a case definition of mTBI was published, by the Mild Traumatic Brain Injury Committee of the Head Injury Inter-disciplinary Special Interest group of the American Congress of Rehabilitation Medicine (ACRM)(Kay, et al., 1993), which required just a single criterion of unconsciousness, amnesia or an alteration in mental status for the diagnosis of mTBI (see chapter 3 of this thesis). This was a significant step forward, because it enabled mTBI to be diagnosed without LOC, which had previously been held to be essential for the diagnosis. This definition, supported by ongoing research, has led to acceptance that mTBI does not always involve LOC.

One year later the fourth edition of the Diagnostic and Statistical Manual for Mental Disorders (DSM-IV) (American Psychiatric Association, 1994) included a set of criteria for studying Post-concussional Disorder (PCD). It was recommended that a diagnosis of PCD should only be made three months post-injury, and that the individual must have experienced at least five minutes of LOC. Although a definition of mTBI was not given in the DSM-IV, this inclusion of LOC in the definition of PCD was not compatible with the ACRM definition. Various attempts have been made to solve this contradiction (Ruff & Jurica, 1999). In 2004 the World Health Organization (WHO) Collaborating Centre Task Force (Carroll, et al., 2004a), stating that the literature would greatly benefit from common criteria, recommended an operational definition derived from the ACRM definition, which does not require LOC for a diagnosis of mTBI.

4.2.2 Interventions for mild TBI.

A large number of people experience post-concussion symptoms (PCS) following a mTBI. Symptoms experienced in the days or weeks following injury include headaches, dizziness, sensitivity to noise and/or bright lights, blurred or double vision, restlessness, insomnia, reduced speed of thinking, poor concentration and memory problems. Although in the majority of cases these symptoms resolve within three months of injury, up to 20% of those who suffer an mTBI continue to experience cognitive difficulties, physical symptoms and poor psychosocial outcomes for months or even years post-injury (Binder, 1986a). As described in chapter 2 of this thesis, when this constellation of symptoms persists following a mTBI, it is commonly termed post-concussion syndrome.

Despite the magnitude of this problem, papers describing post-concussion syndrome and its assessment greatly outweigh investigations of interventions and treatments for it (King, 2003). One reason identified for this is a lack of well-designed prognostic studies to define the prevalence, character and risk factors for persisting symptoms, as a starting place for further research (Ponsford, 2005). Borg et al. (2004), in a comprehensive review of the literature published between 1980 and 2002 as part of the WHO Collaborating Centre Task Force, reported that the best evidence on management strategies for mTBI in adults is provided by five studies. Three of these studies compared an educational intervention with usual hospital services: a small RCT by Mittenberg, Canyock, Condit and Patton (2001) and two RCTs from Oxford in UK (Wade, Crawford, Wenden, King, & Moss, 1997; Wade, et al., 1998). The other two studies investigated whether a single-session intervention was as effective as more elaborate assessment and therapy (Paniak, Toller-Lobe, Durand, & Nagy, 1998; Paniak, et al., 2000). Taken together these studies provide some evidence that early educational information can reduce long-term complaints, and that this early intervention need not be intensive (Borg, et al., 2004). Additionally, a trial by Alves Macciochi and Barth (1993) which randomly assigned 587 patients to routine, information-only or information-and-reassurance groups, suggested that reassurance is an important element of early educational interventions

It is noteworthy however that there are very few reported studies investigating the provision of information and reassurance after mTBI with non-hospitalised patients, even though most individuals with such injuries are not admitted to hospital (Ponsford, 2005). Only one of the investigations cited above (Wade, et al., 1997) compared a treatment intervention with standard services in both hospitalised and non-hospitalised patients. This study, which is described in more detail in the section on community-based interventions later in this chapter, aimed to evaluate whether offering a routine early follow-up service to patients presenting to hospital with a head injury, of any severity, affected their outcome six months later. Most patients (78%) were admitted to hospital. This study failed to find a significant benefit to the group who were given information and reassurance about their injury, although a subgroup analysis indicated that patients who had sustained a more severe category of mild injury—that is those who had been hospitalised following their injury or PTA of at least one hour—do benefit from routine follow-up.

One RCT (Ponsford, et al., 2002) has looked at outcomes following provision of educational information in non-hospitalised mTBI patients. This study aimed to establish whether early assessment, and the provision of written information and suggested coping strategies, could reduce the incidence of PCS three months after injury in individuals who were not admitted to hospital. A sample of 202 adults with mTBI was recruited from consecutive presentations to the EDs of two hospitals. Participants in the intervention group (*n* = 72) were seen one week post-injury, when a detailed history was taken, a neuropsychological assessment performed and a booklet outlining common symptoms associated with mTBI, their likely time course and suggested coping strategies was given. No specific feedback was given regarding the results of the assessments conducted. The non-intervention group patients (*n* = 123) received standard ED treatment only and were not given the information booklet. Both groups were assessed three months post-injury. At the three-month follow-up patients in the intervention group reported fewer symptoms and were significantly less stressed than those in the control group.

One other randomised trial of treatment for mTBI patients presenting to ED (Ghaffar, McCullagh, Ouchterlony, & Feinstein, 2006), showed improvements in emotional functioning, but only in those with pre-injury psychiatric difficulties (22.9% of the sample), suggesting that targeting patients with these problems may be more appropriate than providing treatment for all mild injuries.

4.3 Interventions Following Moderate to Severe TBI

A number of problems are encountered when attempting to judge the efficacy of interventions for more severe TBI. Randomised controlled trials (RCTs) are commonly taken to be the "gold standard" for evaluating the strength of evidence for medical interventions. However this type of evidence is very difficult to obtain with the TBI population because of practical and ethical restraints on withholding treatments for severely injured patients, who do not have recourse to alternatives. Another problem is that TBI is very complex and heterogeneous and two individuals with the same injury-severity may have very different patterns of impairment, with different prognoses and different rehabilitation needs. This is complicated by a lack of agreement on instruments and measures, even in areas as basic as injury-severity (see chapter 2). Rehabilitation after TBI is a long-term process taking months or even years, which makes measurement of outcome difficult in practical terms. There are also significant problems in judging outcome. Although most health professionals would agree that the best measure is quality of life, this is difficult to measure; most studies revert to less satisfactory, but more measurable, outcomes such as productivity or work (Chesnut, 1999).

A number of recent reviews of the rehabilitation field have helped to draw together the evidence for progress made, and highlight areas of weakness that need to be addressed. In USA, a National Institutes of Health (NIH) consensus conference (National Institutes of Health Consensus Development Panel on Rehabilitation of Persons With Traumatic Brain Injury, 1999) identified a need to confirm which rehabilitation interventions are effective through well-designed and controlled studies and the characteristics of individuals who will benefit from them—"what works for whom". The focus of the conference was the evaluation of rehabilitative measures for the cognitive and behavioural consequences of TBI. While pointing out that research in this area was limited, the conference report stated that scientific evidence supports the use of certain cognitive and behavioural rehabilitation strategies, and that effective interventions share a number of certain characteristics: They are structured, systematic, goal-directed and individualised; and involved learning, practice, social contact and a relevant context. The consensus panel also pointed out that the epidemiological data suffer from ascertainment bias, since they are based exclusively on information about hospitalised patients. As a result mTBI is significantly under-diagnosed and early intervention is often neglected.

A systematic review of the effectiveness of TBI rehabilitation (Chesnut, 1999) highlighted limitations in research design, methods of analysis, patient selection, and relevant outcome measures, but reported that the strongest studies suggest positive effects from early intervention on recovery after TBI (Cope & Hall, 1982), compensatory cognitive rehabilitation (Carney et al., 1999) and supported-employment (Haffey & Abrams, 1991). These researchers also pointed out that the limitations highlighted call into question the results of the many studies with negative findings: lack of observed treatment effect may be due to inadequate design and not to lack of treatment efficacy.

A review of evidence-based recommendations for the clinical practice of cognitive rehabilitation (Cicerone, et al., 2000) found clear evidence supporting its effectiveness for the impairments of attention, functional communication, memory and problem solving after TBI in eight prospective RCTs. This type of program has been shown to improve community functioning (Cicerone, Mott, Azulay, & Friel, 2004; Goranson, Graves, Allison, & La Freniere, 2003; Malec, 2001; Seale et al., 2002), while specific neuropsychological interventions for deficits in memory, attention, and executive functioning have also been found to be effective; (Fasotti, Kovacs, Eling, & Brouwer, 2000; Gordon, et al., 2006; Sohlberg, McLaughlin, Pavese, Heidrich, & Posner, 2000)

A review of TBI rehabilitation research by Gordon et al (2005) examined literature published between 1998 and 2004. The authors addressed some of the questions arising from the NIH consensus conference, and reported that a clearer understanding of who gets injured and some of the factors relating to their recovery had emerged. However in terms of evaluating the efficacy of interventions, or of developing new treatments, less had been accomplished. Previous findings that comprehensive holistic cognitive rehabilitation improves community functioning were confirmed, and it was noted that specific neuropsychological interventions for deficits in memory, attention, and executive functioning had also been found to be effective. Weaknesses highlighted include the finding that in studies of outcome, samples were often small, and rarely representative of the TBI population. Furthermore, although strong evidence was found to suggest that TBI results in disturbances of mood (depression and anxiety disorders) and antisocial behaviour (for example substance abuse) information on interventions, be they psychological, behavioural or pharmaceutical, was found to be inadequate to guide effective practice.

In 2005 a Cochrane review (Turner-Stokes, et al., 2005) looked at the evidence, from RCTs for the effectiveness of multidisciplinary rehabilitation following acquired brain injury (ABI) in adults of working age, across a range of injury severities. It is important to note that this review was of acquired brain injury, which includes non-traumatic injuries such as those from stroke. However, the majority of studies were of TBI (9 out of a total of14 trials were of TBI). For moderate to severe brain injury this review found *strong evidence* of benefit from formal intervention—more intense inpatient programmes were associated with earlier functional gains—and there was *moderate evidence* that continued outpatient therapy can help continue the gains made in early post-acute rehabilitation. Some recommendations from the review were that patients presenting acutely to hospital with moderate to severe injuries should be routinely followed-up to assess their need for rehabilitation, and patients discharged from in-patient rehabilitation should have access to out-patient, or community-based services, appropriate to their needs. It also found *strong evidence* that most individuals with milder injuries make a good recovery with provision of appropriate information and advice. A subsequent review (Turner-Stokes, 2008) of non-trial based methods—such as cohort analyses and qualitative studies—found strong evidence supporting and extending the Cochrane Review findings, indicating that there is now a substantial body of high-quality research evidence for the effectiveness, including cost effectiveness (Khan, Khan, & Feyz, 2002; Murphy et al., 2006; Wood, McCrea, Wood, & Merriman, 1999) of rehabilitation for TBI.

4.4 Current Trends in TBI Rehabilitation

Over the last twenty years a major shift in health care has occurred towards increased accountability of rehabilitation, with a push towards increased efficiency, reduced costs and shorter rehabilitation periods. One effect of this has been the development of functional rating scales, more specific to TBI than to general medical rehabilitation programs. These scales have evolved from global outcome measures, such as the Glasgow Outcome Scale (GOS; Jennett & Bond, 1975) and the Disability Rating Scale (DRS; Rappaport, et al., 1982), to more focused measures, such as the Community Integrated Questionnaire (Willer, Rosenthal, Kreutzer, Gordon, & et al., 1993), that reflect actual targets of treatment. At the same time a realisation has grown that the subjective experience of patients must be measured with scales such as the Quality of Life Inventory (Frisch, Cornell, Villanueva, & Retzlaff, 1992).

There has also been a move to develop practice standards and guidelines, and to articulate patients' rights and the ethical guidelines by which rehabilitation services operate. As part of this, professional groups have pushed for more information about the levels of evidence for interventions that work, resulting in reviews of rehabilitation interventions, several of which are outlined above. Cognitive rehabilitation, in particular, has aroused a great deal of scepticism and controversy, despite widespread acceptance by TBI professionals (Cope, 1995; Mazaux & Richer, 1998). As a result cognitive rehabilitation has been one of the most thoroughly researched areas of TBI rehabilitation (Boake & Diller, 2005).

Comprehensive guidelines for rehabilitation across the continuum of care, have been developed in UK for ABI (British Society of Rehabilitation Medicine & Royal College of Physicians, 2003), and in New Zealand for TBI (New Zealand Guidelines Group, 2006). Guidelines in other countries target different stages in the continuum of TBI rehabilitation.

A number of studies, (for example Fakhry et al., 2004) have been completed in USA, to measure the implementation of acute care guidelines developed by the Brain Trauma Foundation (2006, 2007, 2008). These studies identified that adherence to protocols based on these guidelines had resulted in reduced mortality and length of stay in acute care and hospital settings.

4.4.1 Community-based interventions.

There is limited information about community-based interventions, but a number of reports suggest that they are effective in improving outcomes, including increased productivity and improved societal participation and adjustment in the post-acute phase, for TBI patients of all severities

The Cochrane review of RCTs of rehabilitation for ABI in adults of working age (Turner-Stokes, et al., 2005) reports on only two community-based interventions, one of which (Bowen, Tennant, Neumann, & Chamberlain, 2001) is a community-based intervention for carers of people with TBI, not an intervention for those who have been injured. The other study (Powell, et al., 2002) is the first RCT of multidisciplinary community rehabilitation after severe TBI. It was made possible because of the availability of Department of Health funding in the UK for ten "model" services for TBI patients. As the service was new, it was possible ethically to offer it on a randomised basis, and this resulted in a good quality, single-blind RCT of a multidisciplinary community outreach service providing a home-based goal-orientated programme, two to six hours per week, compared with standard treatment. Based in the urban setting of east London, the multidisciplinary team comprised two occupational therapists, a physiotherapist, a speech and language therapist, a clinical psychologist, and (intermittently) a half-time social worker; it was directed clinically by a clinical psychologist.

Participants were 110 individuals who had sustained at least a moderate TBI, as indexed either by a retrospective estimate of PTA exceeding 24 hours, or by other neurological evidence. Participants were divided into two groups, half receiving the outreach rehabilitation programme, and half a single visit at home from a team therapist who gave the participant a booklet with information about a wide range of local and national resources, and highlighted those most relevant to his or her needs. Those allocated to the treatment condition participated in an individualised program, and were typically seen in their own homes or other community settings (day centres, colleges, workplaces) for 2–6 hours a week. A goal planning framework was developed within which long-term goals, valued by the client and their carer, and considered amenable to intervention by the team, were worked towards via a series of written contracts which specified interim and short-term goals achieved over 6-12 weeks. These provided the basis for reviews, at which decisions were taken about subsequent contracts or temporary/permanent cessation of treatment. After the initial assessment period, participants were seen twice-weekly for an average of 27.30 weeks. Median time since injury was 1.37 years but ranged between 3 months and 20 years, with 14.9% of participants being within 6 months, 41.5% within a year, and 74.5% within four years of injury.

Forty eight outreach and forty six information participants were followed up after a period of 18 to 40 months, by a research worker who was independent of the outreach team and was kept blind to participants' treatment allocation. Results showed that participants in the treatment group were more likely to show significant gains on the Barthel Index (Collin, Wade, Davies, & Horne, 1988), and the brain injury community rehabilitation outcome-39 total score and self-organisation and psychological wellbeing subscales (BICRO-39; Powell, Beckers, & Greenwood, 1998). Forty percent of the treatment group, but only 20% of the information group made a clinically significant improvement of 2+ points on at least one of the BICRO-39 scales. Time since injury was unrelated to the magnitude of gains.

This is an important study for a number of reasons: it is the first RCT of community rehabilitation following TBI and it gives initial information that relatively inexpensive outreach community services can enhance a variety of outcomes following TBI, irrespective of the time post-injury. It is well designed and well reported (Hillier, 2003) and describes the intervention used making it accessible to replication and adaption, in contrast to many other study which use a “black box” approach, which does not specify the intervention. It is notable that the treatment group failed to make durable gains in socialising or productive employment, but the authors suggest that this may be because these domains, which involve increased activity outside the home, are more subject to obstacles beyond the direct control of both the injured individual and the therapist, than other domains. Altering some of the elements of therapy may have a positive effect, and enable gains in those areas to also be made.

In the section on “milder ambulatory patients”, the Cochrane Review also reports on two RCTs from the UK. These two studies, which are frequently cited as providing support for interventions for mTBI, actually report on a community intervention for head-injuries of all severities. The results suggest benefits from routine early intervention for all TBI patients with PTA of at least one hour, but not more than seven days.

The first (Wade, et al., 1997) aimed to evaluate whether offering a routine follow-up service consisting of additional information, advice and support, to patients presenting to hospital following a head-injury affects outcomes six-months later. This study used a large sample (*n* = 1156) but failed to find significant differences overall between a trial group of 252 patients and a control group of 266 patients who were followed up six months post-injury. However many patients assessed had sustained only very mild injuries (48% had no PTA or LOC). Subgroup analyses comparing the trial and control patients with more severe head injuries demonstrated that those who were admitted to hospital, or had PTA of at least one hour (*n* = 131) did demonstrate significant gains with treatment. The lack of significant differences in this trial may be at least partially attributed to the large proportion of very minor injuries, many of which may not have met the criteria for TBI because the inclusion criteria did not distinguish between superficial head injuries without PTA or neurological signs, and injuries to the brain.

The second RCT (Wade, et al., 1998) looked at the benefits of an educational intervention in hospitalised patients. Participants were 314 patients aged 16-65 years admitted to hospital after a head injury of any severity. 184 were randomised into the intervention group and 130 into the control group. Patients in the control group received existing hospital services, which did not include routine follow-up of uncomplicated head injuries. Patients in the trial group were contacted 7—10 days after injury and given an intervention booklet. Clinicians aimed to see patients face-to-face whenever possible. When this was not possible they were telephoned, and when it was impossible to contact the patient by telephone or in person, an information booklet was posted to them. This was accompanied by a letter with a tear-off slip to return if they wished to speak to someone about their head injury. All patients were assessed at follow-up six months post injury. This study found significantly less social disability and significantly less PCS in the intervention group compared with those who did not receive the intervention. The impact of proactive intervention appeared to be most marked for patients with PTA up to seven days, who, the authors suggest, may be less likely than those more severely affected to present to services by themselves. However, because the majority of patients seen at six months needed reassurance, advice or other services, they suggest that monitoring of patients for some time after injury is warranted.

The intervention used in these two trials was undertaken by the Oxford Head Injury Service. This service and the interventions it implemented in the two RCTs are reported separately in detail, making them easily available for replication (King, Crawford, Wenden, Moss, & Wade, 1997). Extensive use was made of five standardized leaflets, in conjunction with individualised assessment and advice. Care was taken about the type of information and advice that patients were given, in order to avoid encouraging the possible emergence of symptoms (by creating an expectation of them), giving an unrealistic time-scale relating to the improvement/recovery of symptoms or encouraging patients to become preoccupied with symptoms. The authors suggest that a population of 560,000 could receive the services described in this study, from three full-time equivalent (FTE) staff plus administrative support.

A more recent study (Snell & Surgenor, 2006) outlines the characteristics of referrals to a specialist clinic for mTBI in New Zealand over a one-year period. This clinic was initiated to provide early and time-limited rehabilitation in the community for mTBI patients referred from a number of sources, including the local hospital ED, primary health care providers and neurological services. Files for all patients treated at the clinic over a two-year period (n = 357) were reviewed, to gather data on referral source, age, gender, cause of injury, details of treatment received in the clinic and information about outcome. The majority (56%) of patients were seen by both a specialist medical practitioner and an allied health practitioner, with neuropsychology being the most likely second discipline involved (43%), followed by occupational therapy (34%) and physiotherapy (25%). One hundred and sixty four patients were offered follow-up treatment over several months, mostly (57%) with a single health practitioner (an occupational therapist or physiotherapist in 51% and 23% of the cases respectively). Twenty two percent of the patients offered treatment were seen for more than seven months. At point of discharge 70.2% of cases were classified as having a good outcome, with others classified as fair (11.8%) or poor (6.2%).

In comparison with epidemiological studies, which typically report rates of TBI two to three times higher in males compared with females (Fortune & Wen, 1999;

Kraus & McArthur, 1999), referrals to this clinic was reasonably gender-balanced (57% males) suggesting that males may have been under-referred. Cause of injury was associated with gender, with females less likely to have experienced an assault or a workplace accident, and more likely to present secondary to a medical condition such as a fall, resulting from syncope or seizure. One fifth of injuries were caused by an assault. Excluding cancellations, there was a 10% failure to attend rate, with younger patients more likely to fail to attend. The ED of a local hospital was the referring service, with the largest percentage of cases (19%) that did not attend. The authors suggest that this may be because patients may have recovered between attending emergency and the concussion clinic appointment, and/or the fleeting therapeutic engagement involved in attendance at the ED may have reassured them. The variables associated with being a long-term case were gender (being a woman), a longer time from injury to clinic assessment (mean of 12.2 weeks compared with mean of 8 weeks $p = 0.039$) and cause of injury. Injuries secondary to medical conditions (75%) and other miscellaneous causes (80%) were more likely to be long-term cases.

The studies reviewed in this section indicate that interventions in the community can be effective for TBI patients with a wide range of injuries. They also provide important information about factors to consider, when designing a community-based intervention. For example, the trials in UK suggest that routine follow-up may not be warranted for all injuries, irrespective of severity, and outline the potential dangers of offering bland reassurance and general advice without specialist assessment. The experience from the New Zealand study, in which ED referrals had a high fail-to-attend rate, suggests that referral from ED may not always be the best use of resources. It may be more appropriate for the contact details of mTBI patients at risk of poor outcomes, to be passed to rehabilitation services who can then contact them, seven to ten days post-injury to assess their follow-up needs.

4.4.2 Access to rehabilitation.

Despite the substantial body of evidence for the effectiveness of rehabilitation interventions, across the spectrum of injury-severity, and throughout the continuum of care, research in USA and UK indicates that only a small proportion of TBI patients, who could benefit from rehabilitation services, gain access to them (Dombovy & Olek, 1997; Mellick, Gerhart, & Whiteneck, 2003; Wade, et al., 1998). For example, two thirds of those suffering a TBI in a population-based sample in USA received no additional services following discharge from an acute care hospital. Six post-acute hospitalisation pathways were identified based on combinations of inpatient rehabilitation, community-based services and long-term care. In each category—except for the one involving discharge directly from acute care to home—people with the most severe TBIs were over-represented (Mellick, et al., 2003). In UK, a study of a large representative cohort of adults with TBI admitted to hospital (*N* = 2692, of which 549 were followed up) found that only 28% reported having received input from rehabilitation services, one-year post-injury (Thornhill, et al., 2000). Survivors of this group were subsequently followed up five to seven years post-injury. Although clear evidence was found of associations between adverse self-ratings of emotional well-being and moderate or severe disability which potentially may be open to remediation, so few of the participants studied reported having received rehabilitation that the researchers concluded that there could be no meaningful analysis of the possible effects of this intervention (Whitnall, et al., 2006).

4.5 TBI Rehabilitation in Australia

There are currently no national guidelines for TBI rehabilitation in Australia, but in New South Wales there are some for the care of people living in the community following a TBI (Trevena, Cameron, & Porwal, 2004), and for rehabilitation of mTBI (Motor Accident Authority of New South Wales, 2008). More information is needed about rehabilitation services in Australia and the factors that influence referral to them (Foster, Tilse, & Fleming, 2004; Graham & Cameron, 2008). Some studies suggest that services in the community are below international standards: O'Callaghan et al. (2010) in a study of 202 patients' experience of care in the state of Victoria, over four years following moderate to severe TBI, report that just over half of all participants reported that they were neither receiving therapy nor ongoing monitoring, despite the recommendation that TBI patients with significant injuries should have long-term access to an individual or team with experience in the management of brain injury (British Society of Rehabilitation Medicine & Royal College of Physicians, 2003). The majority made comments related to the lack of services available to them on discharge. Furthermore an examination of received services, length of stay in services and funding, indicated there were variations in rehabilitation based on funding. Funding issues have also been shown to affect access to medical and rehabilitation services for TBI patients overseas (Johnstone, Nossaman, Schopp, Holmquist, & Rupright, 2002; Schootman & Fuortes, 1999), with those in rural areas commonly receiving fewer services.

A qualitative study of the service needs of individuals with ABI and their families (Turner, Fleming, Ownsworth, & Cornwell, 2011) highlighted the difficulties participants experienced in negotiating the rehabilitation process between hospital and home. The findings suggest that the scope of existing service models needs to be extended to bridge the gap between inpatient and community services, thereby easing the impact of transition.

Like many other developed countries, Australia has three models of health-care funding: private, public and compensable. Compensable funding is available for road traffic accidents and for some work-place accidents. Compensable schemes pay “reasonable” medical and rehabilitation costs, income assistance, travel and household support. Those with private funding receive services paid for by their private health insurance, the nature and extent of which depend on the options that they chose to purchase before their accident or injury. Once a person has used up their allocated private health care funds they become a public patient and their continuing services are paid for by public funds. Publically funded clients receive services provided by the Australian federal and state governments from monies raised from tax revenue and other sources.

The bulk of medical and rehabilitation services and long-term care following TBI in Australia is publically funded. However a report of the Health department of Victoria in 1991 (Health Department of Victoria, 1991) suggested that at that time TBI survivors who accessed rehabilitation in the private sector through insurance or worker’s compensation were better served, and had more options, than clients not covered. This report also suggested that TBI services tend to be centralised in metropolitan and large regional centre, resulting in inequity of access for rural clients. A number of recommendations were made by the authors to improve equity of access to rehabilitation, regardless of compensation status or location. However O’Callaghan, McAllister and Wilson in a follow-up review report that national and international publications, anecdotal report and clinical experience suggested that sixteen years later little had changed in Victoria (2009).

A recent Australian study (Harradine et al., 2004) found no difference in injury-severity, length of acute care stay and functional outcome—including return to work—between rural and urban TBI patients attending the Brain Injury Rehabilitation Programs (BIRPs) in New South Wales. These programs are a unique state-wide network of services that provide brain injury rehabilitation in 11 centres located throughout New South Wales, in both urban and rural areas. However, although this study found no statistical differences in urban versus rural outcomes, its authors acknowledge that rural clients face more challenges in their rehabilitation, because they often need to travel long distance to access services. Furthermore this study looked only at rehabilitation for severe TBI, and did not report on access to services for those with mild to moderate TBI.

4.6 Limitations in Previous Research

Much of the literature on rehabilitation effectiveness focuses on people receiving specialist TBI rehabilitation. An area of weakness highlighted by the NIH consensus conference, and subsequently by the review by Gordon (2006), is that the majority of studies are of those patients who have been admitted to hospital, or those whose injuries have been classified as severe or moderate (Wenden et al., 1998a). Even when mild injuries have been included they are often limited to those admitted to hospital (Mittenberg, et al., 2001; Paniak, et al., 2000). This means that current epidemiological and outcome data suffers from ascertainment bias since they are based almost exclusively on information about hospitalised patients. As a result mTBI is significantly under-diagnosed and early intervention is often neglected (National Institutes of Health Consensus Development Panel on Rehabilitation of Persons With Traumatic Brain Injury, 1999). The generalisation of findings from studies of rehabilitation which include only moderate to severe TBI is also questionable, because, as reviewed above, rehabilitation interventions for mild injuries are different from what is required for more severe TBI (Turner-Stokes, et al., 2005).

4.7 Summary and Research Directions

In summary, rehabilitation for TBI was made possible by advances in medicine in the twentieth century, and developed in response to the large number of people who incurred a TBI in World War 1. Early pioneers in Germany developed approaches on an ad hoc basis, and these were subsequently modified in the light of experience, both there and in other countries—notably USA, UK and the Soviet Union. Based on the observation that the residual cognitive, emotional and behavioural sequelae of head injury greatly exceed the physical as a cause of difficulties, a holistic neuropsychological rehabilitation outpatient program was developed in Israel in the 1970s. This program, usually called cognitive rehabilitation, has proven efficacy and has been emulated in many countries for the rehabilitation of moderate to severe TBI. Despite the fact that 80% of TBIs are mild, and a percentage of cases result in long-term sequelae, little attention was paid to developing therapeutic interventions for mTBI until the 1990s, when it was demonstrated that early educational interventions can reduce long-term symptoms.

There is now a substantial body of high-quality research evidence for the effectiveness of rehabilitation interventions for TBI of all severities. However, much of the literature focuses on people receiving specialist TBI rehabilitation, and the majority of studies consist of patients who have been admitted to hospital. Even when mild injuries have been included they are often limited to those admitted to hospital. A number of descriptions of community-based interventions, including a report of a RCT for community rehabilitation following severe TBI, indicate that community-based rehabilitation can be effective in improving outcomes for TBI patients with ongoing difficulties, in all categories of severity. Importantly they have been shown to improve outcomes in those who are not admitted to hospital, but have ongoing problems.

Over the past 20 years there has been increased accountability of rehabilitation which has resulted in the development of standards and guidelines for TBI rehabilitation in some countries. Research has indicated benefits when these guidelines are adhered to, but services often do not match up to them, and there is a gap between inpatient and community services. In Australia comprehensive national guidelines for rehabilitation following TBI have yet to be developed. There is currently limited information about rehabilitation services but evidence suggests that they are influenced by funding and location.

To obtain a clearer picture of the extent to which existing services are meeting the rehabilitation needs of the full spectrum of TBI patients with ongoing disabilities, comprehensive descriptions of the types of care allocated at the end of the acute phase of TBI, and the factors that influence variation in referral and access to services are needed. In particular it will be useful to have detailed information on referral, offers of appointments from various rehabilitation disciplines, and amounts and nature of therapy provided in order to better understand the rehabilitation processes.

The research summarised in this chapter suggests that in developing a model of pathways of rehabilitation it will be important to consider the following factors:

- The whole spectrum of TBI severity needs to be considered, not just hospitalised cases and/or those with moderate to severe injuries
- Although the majority of mTBI patients recover spontaneously, some have ongoing problems, which can be prevented or ameliorated with early intervention.

- Screening to identify mTBI patients most at risk of poor outcomes will ensure the best use of resources, rather than attempting to provide indiscriminate follow-up for everyone who sustains a mTBI.
- Although educational interventions have been shown to be effective there are dangers in offering bland reassurance and general advice which may, for example, encourage the emergence of symptoms by creating an expectation of them.

4.8 The Current Research

Tasmania, one of six states in Australia, is an island with a total population of 500,000 and one tertiary referral centre, the Royal Hobart Hospital (RHH). In December 2003 the Tasmanian Neurotrauma Register (TNTR) commenced a population-based prospective TBI outcome study, as a joint initiative of the University of Tasmania and the RHH. It was funded from 2003 until 2008 by the Motor Accidents Insurance Board. The Motor Accidents Insurance Board is a Tasmanian Government Business Enterprise which gives medical and income benefits on a no-fault basis to persons injured in motor vehicle accidents while, enabling access to common law.

The TNTR project attempted to recruit all individuals over the age of 16, including those not admitted to hospital, who presented following a TBI to the Emergency Department (ED) at the RHH. Outcome data were collected from participants at baseline, one-month, three-months, six-months, twelve-months and then annually for up to five years post-TBI, by research assistants, most of whom were provisionally registered psychologists studying for a post-graduate qualification in clinical psychology. The establishment of this database and research programme provided the opportunity to look at patterns of referral to rehabilitation in a population-based sample, which included injuries across the spectrum of severity from very mild to very severe. Moreover, the collection of demographic and injury-related information close to injury, and scores on a wide range of measures at regular intervals post-injury, provided data by which to assess those who accessed rehabilitation services.

The aim of the present research was to investigate patterns of referral to outpatient rehabilitation services in the TNTR sample, to look at a range of demographic, injury-related and post injury factors in those referred to public post-acute community rehabilitation and investigate how they were referred to progress in rehabilitation.

The next chapter, chapter 5, will outline some of the principles and theories of rehabilitation and current recommendations about how services for rehabilitation should be organised. It will also provide an overview of the services available for TBI rehabilitation in Tasmania during the course of the present research.

CHAPTER 5 - Rehabilitation Services

Rehabilitation is the multi- and inter-disciplinary management of a disabled person's functioning and health. A useful definition, developed by the British Society of Rehabilitation Medicine (British Society of Rehabilitation Medicine, 2003 #813}, looks at rehabilitation in terms of concept and service:

> **Conceptual definition:** A process of active change by which a person who has become disabled acquires the knowledge and skills needed for optimal physical, psychological and social function.
>
> **Service definition:** The use of all means to minimise the impact of disabling conditions and to assist disabled people to achieve their desired level of autonomy and participation in society.

In the past 20 years there has been a move away from a *medical model*, which views disability as a feature of the person, directly caused by disease, trauma or other health conditions. This assumed a linear pathway from pathology through impairment to disability and on to handicap, and called for medical or other treatment or intervention to "correct" the problem with the individual. It therefore tended to reinforce a clinician-based, hospital-dominated approach focused on impairment, with little attention given to the processes by which disability comes about or the interventions whereby reintegration into society could be facilitated. A *social model* of disability, on the other hand sees disability as a socially-created problem. It puts responsibility back onto society to allow disabled individuals to function to the best of their ability. Furthermore it recognises the influence of the physical and social environment, and personal factors, such as beliefs, behaviour and coping style on health and disability.

On its own neither the medical or the social model is adequate, because disability is always an interaction between features of the person and features of the overall context in which the person lives. Because both medical and social responses are appropriate to the problems associated with disability, a more useful model of disability is the *biopsychosocial model*, which synthesises what is true in each of the models. This is provided in the World Health Organization's framework for health and disability: the WHO International Classification of Functioning, Disability and Health (ICF; World Health Organisation, 2001). The ICF puts the notions of "health" and "disability" in a new light. It acknowledges that every human being can experience a decrement in health, and thereby experience some degree of disability. It thus "mainstreams" the experience of disability and recognises it as a universal human experience.

The diagram in figure 5.1 is a representation of the model of disability that is the basis of the ICF.

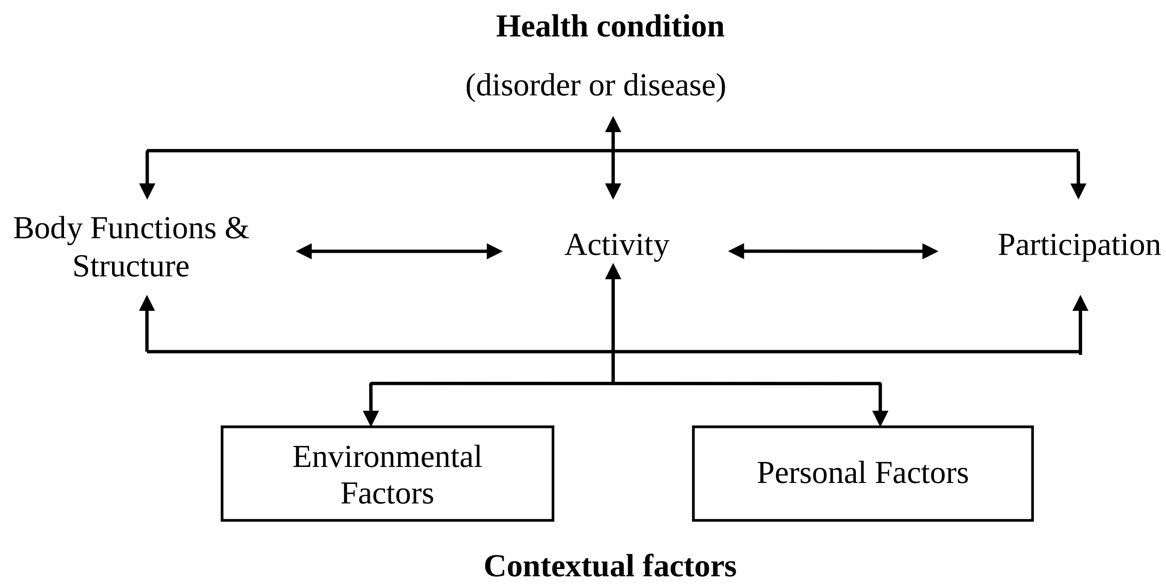


Figure 5.1 A Representation of the Model of Disability that is the Basis for ICF (World Health Organisation, 2001)

5.1 The Rehabilitation Process

The goals of rehabilitation are to minimise symptoms and disability, through a process of restoration of function or compensatory strategies. The objective is to maximise the patient’s behavioural repertoire and to optimise his or her environment, while also helping with emotional distress in both the disabled individual and family members and carers.

Rehabilitation is an ongoing process which works towards achieving these objectives. It begins with an assessment of the disabled person’s range of problems. There is an early focus on participation in society, and attention is given to potentially disabling behaviours and environmental factors that increase disablement, and thus limit participation, and potentially beneficial behaviours and environmental factors that help to minimize symptoms and disability, thereby increasing participation. Patients typically have a range of problems such as physical symptoms, mood disturbance, difficulties with activities of daily living and participation restrictions. As everything cannot be targeted simultaneously, it is necessary to set priorities and address factors with the greatest potential for improvement. A number of goals are set and these are worked upon in a specific time-frame using agreed intervention strategies. In this process, the disabled person’s strengths and wishes are acknowledged, as well as those of their support team. Through a consultative process, an intervention or interventions are chosen that are specific, measurable, attainable and time-limited to meet the person’s goals. At the end of the time period the intervention is assessed and if necessary new targets may be set for further iterations of this cycle (Stucki, et al., 2003).

5.1.1 Stages of rehabilitation.

There is no agreed classification of rehabilitation interventions and programmes, but they may be described in terms of setting and content, as outlined below.

- **In-patient settings:** where rehabilitation is delivered in the context of 24-hour care in a hospital or specialist unit
- **Outpatient or day treatment settings:** these may also be in a hospital setting, or may be in a day centre or a specialist rehabilitation unit
- **Community or home-based settings:** these include outpatient therapy for achieving physical, domestic and social independence, reduction of handicap and re-entry into the community.

Mazaux (1998) identified three phases of rehabilitation following TBI: acute, sub-acute and post-acute. The acute phase takes place during coma and arousal states and aims to prevent orthopaedic and visceral complication and provide sensory stimulation to accelerate arousal. The sub-acute phase, which is generally inpatient, commences at the termination of coma and is designed to facilitate and accelerate recovery of impairments and compensate for disabilities. Motor abilities, cognition, behaviour, personality, affect and self-awareness are simultaneously addressed in a multi- or inter-disciplinary context. Ideally outpatient or day treatment continues this process in a hospital, day centre or specialist rehabilitation unit, following discharge from the inpatient setting. This is followed by post-acute rehabilitation in outpatient settings, with the aim of achieving physical, domestic and social independence, reduction of handicaps and re-entry into the community. Because disabilities resulting from TBI may be life-long, a fourth stage, consisting of longer-term community support to assist in maintaining gains, may also be usefully added to this model.

When thinking about rehabilitation in terms of stages, the critical point is that TBI patients will have different requirements, and the same patient will have different needs at different stages of the rehabilitation process. At the very severe end of the spectrum, patients may require total care for the rest of their life. Those with less severe injuries may return home, but need ongoing, life-long support in order to adjust to and live with their level of disability. A much larger group, the so called "walking wounded", will suffer an apparently mild injury and appear "normal" to all extent and purposes, but subsequently have high-level cognitive deficits, such as memory and attentional problems, or altered personalities, which disrupt their lives and those of friends and families. Clearly these groups require very different interventions from health professionals with different skills and training. It is this heterogeneity of possible impairments which necessitates a range of different rehabilitation services, and makes it vital to have effective communication between them.

However, rehabilitation following TBI may be different from rehabilitation in general, due to the influence of specific problems, such as executive and memory deficits. Deficits of executive function result primarily from frontal lobe damage, and they affect initiative, insight and planning, and often result in behavioural difficulties. Deficits of memory commonly occur following damage to the temporal lobes.

For these reasons, rehabilitation services for individuals with TBI may need to attend to the following issues:

- Memory problems which may mean that the injured person misses appointments, simply because he or she forgets them.
- A lack of insight into the problems and deficits resulting from the injury. This may range from perplexity about one's own lack of ability to unawareness or

complete denial of the problem, and may compromise the person's ability to appreciate the need for rehabilitation.

- A compromised ability to set goals, to plan, organise and initiate behaviour to achieve them when they are set, and, to inhibit behaviour incompatible with them.
- Cognitive and physical fatigue which are frequent accompaniments of the condition. There may also be mood swings and behavioural difficulties, and the injured person may be swift to argue, difficult to reason with, and deny fatigue.

5.1.2 Service use following TBI.

Service use is commonly looked at in two ways: firstly whether or not a service is used at all (service utilisation) and secondly, how much a service is used (service intensity) (Duan, Manning, Morris, & Newhouse, 1983). Two studies in USA (High Jr et al., 1995; Phillips, Greenspan, Stringer, Stroble, & Lehtonen, 2004), and one in Australia (Hodgkinson, Veerabangsa, Drane, & McCluskey, 2000) document service utilisation after TBI. The Australian study and the study by High Jr et al. (1995) both found that increased severity of injury was associated with greater use of services, with one exception: in USA study use of psychological services was inversely related to injury-severity, with a higher proportion of milder cases accessing these services compared to those with more severe injuries. The other study in USA (Phillips, et al., 2004) found that in the first three months post-injury, the severity of the TBI was not associated with the likelihood of accessing services. In this study an attempt was made to gather data on intensity of service and the results, which are tentative because of small numbers, suggested that intensity of service did increase with increased injury-severity.

Although the Australian study (Hodgkinson, et al., 2000) found that neuropsychology was the allied health service most frequently accessed in the first two years post-injury, all of the studies of utilisation cited above found that traditional rehabilitation services, such as physiotherapy, speech pathology and occupational therapy, were accessed much more frequently than clinical psychology and counselling. A similar pattern has also been reported following paediatric TBI (Greenspan & Mackenzie, 2000).

Hodgkinson et al. (2000) compared service-use in four groups at different times post-injury and found that the nature of services accessed differed over time. Those in the first four years tended to use services which focused on restoration of function, adjustment to disability and community integration. The groups who were six to 17 years post-injury, on the other hand, used services in response to changes in life circumstances, such as the breakdown of a relationship, change in living situation and loss of employment. Unlike the USA studies quoted above, this study found that utilisation remained high in all groups, possibly because of the greater availability of services in Australia, in contrast to countries such as USA where access to services is dependent on financial or insurance status. This study also found than the prevalence of mental illness increased from <1% pre-injury to 16% post-injury, and that participants with a premorbid history of mental illness had attended fewer medical and allied health appointments in the 12 months prior to being interviewed for the study.

5.1.3 Rehabilitation teams.

Deficits resulting from TBI may be generally classified as physical, cognitive, behavioural/emotional and communicative. While overall assessment of problems may be performed by a rehabilitation physician, more detailed assessment and treatment is ideally performed by allied health professionals in a variety of disciplines. For example motor deficits and functional mobility problems may be assessed and treated by physiotherapists, while speech pathologists assess and treat communication difficulties and dysphagia (difficulty swallowing), neuropsychologists provide assessment and treatment of cognition and clinical psychologists provide assessment and therapy for behavioural and emotional functioning. Other allied health professionals who may be involved in the rehabilitation plan are occupational therapists, social workers and dieticians.

Evidence (Semlyen, Summers, & Barnes, 1998) and expert opinion (McElligott et al., 2011) suggest that rehabilitation is most effectively delivered by a coordinated team of professionals from relevant disciplines. Rehabilitation teams following TBI may be multidisciplinary, inter-disciplinary or trans-disciplinary:

- In multidisciplinary teams, health professionals from different disciplines work alongside each other, but not necessarily in close collaboration. Within each discipline, one or more discipline-specific assessments and interventions may be carried out by a member or members of that discipline.
- In inter-disciplinary teams the members work together to plan and implement an integrated rehabilitation programme, often with collaborative interventions and joint therapy sessions.
- In trans-disciplinary teams, the boundaries between individual disciplines are relaxed. A common rehabilitation programme is negotiated and team members share knowledge, skills and responsibilities across traditional disciplinary boundaries.

It is essential that the rehabilitation team has the necessary skills and experience to provide appropriate and context-specific assessments and interventions for individuals with TBI that will enhance their quality of life and their ability to participate in society. However it is also important to acknowledge that assessments and interventions at the level of pathology may also be a necessary part of rehabilitation, in order to ensure that important issues are not missed. For example failing to diagnose depression or prevent post TBI seizures could lead to devastating consequences. Therefore the rehabilitation team needs to have the expertise and skills to undertake assessment and management of people with TBI, at all levels of the ICF model (World Health Organisation, 2001), with an emphasis on the level of participation (New Zealand Guidelines Group, 2006) and ideally should be overseen by an appropriately qualified rehabilitation physician (Australaisan Faculty of Rehabilitation Medicine, 2011; Graham & Cameron, 2008).

With so many individuals involved in the rehabilitation process good communication and coordination are essential. This is required at multiple levels, including service planning, to ensure that health services are linked with other statutory and voluntary service providers, between the different teams involved in each phase of the rehabilitation process, and between professionals working in each of the teams. Some rehabilitation teams find it useful to have a case coordinator, who takes responsibility for coordinating the assessment, management and support for the individual patient.

5.2 Rehabilitation in Tasmania

Rehabilitation services in Tasmania, like all other states in Australia, are delivered in one of two models: private and public.

5.2.1 Private rehabilitation services.

Patients in the private sector are funded by compensable funds or private insurance. In Tasmania, people injured in motor-vehicle accidents are funded by a no-fault accident compensation system administered by the Motor Accidents Insurance Board. Those injured in a work-place accident may be funded by Work Cover, the

Tasmanian state government body responsible for managing workers compensation funds, while individuals with private insurance or their own funds access rehabilitation services through privately owned medical facilities.

Inpatient rehabilitation may be accessed immediately post-trauma through the ED of a public or private hospital, or at a later stage through referral by health professionals in the public system or the individual's general medical practitioner (GP). Community rehabilitation services in the private sector are accessed through appointments with rehabilitation physicians and allied health professionals on a one-to-one basis with little or no opportunity for a team-based approach to rehabilitation. Services in the community, particularly those of GPs, are usually accessed through the public system even for those individuals with private medical insurance or those who are compensable.

5.2.2 Public rehabilitation services.

Services in the public sector are provided by the Department of Health and Human Services (DHHS), an agency of the Tasmanian State Government. For the purpose of service delivery the state is divided into three regions: north, north-west and south. In 2003 a State-wide Strategic Plan (Department of Health and Human Services, 2003) for rehabilitation in the public sector proposed the following model of rehabilitation service delivery:

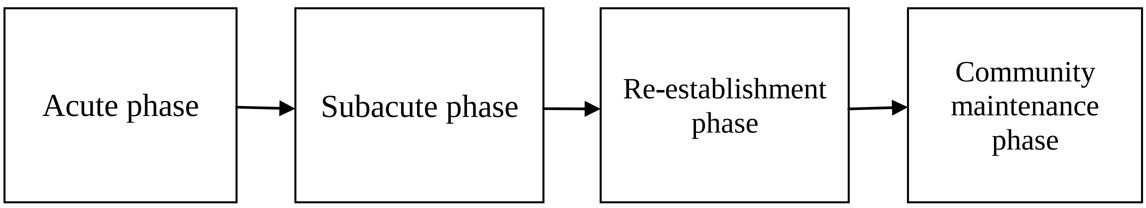


Figure 5.2 Model of rehabilitation service delivery proposed in State-wide Strategic Plan (Department of Health and Human Services, 2003)

The phases depicted in the model are:

Phase One: Acute – A comprehensive multidisciplinary team to provide rehabilitation programs for inpatients within a designated rehabilitation ward, and assessment advice and referral for rehabilitation patients on other wards and units.

Phase Two: Subacute – A multidisciplinary rehabilitation team to provide inpatient assessment, treatment and referral to the community rehabilitation team prior to discharge. A multidisciplinary community rehabilitation team to provide outpatient assessment, treatment and ongoing review.

Phase Three: Re-establishment – A multidisciplinary community rehabilitation team to provide outpatient assessment, treatment and ongoing review. This team provides information and advice about the most appropriate community-based services, and maintains a review register and negotiates transitional support if required.

Phase Four: Community maintenance - The community rehabilitation team to be the point for referral to community services. Community-based allied health services to provide advice and treatment about ongoing maintenance.

Some key elements of this model, described in the document are:

- Multidisciplinary rehabilitation teams in the three major hospitals (in the north, north-west and south of Tasmania) with co-ordinated linkages to community and rural health sites.
- Multidisciplinary community rehabilitation teams in each of the three regions, comprising of a core group of medical and health professionals, including:

  Specialist medical staff

  Rehabilitation team manager

Physiotherapy

Occupational Therapy

Speech Pathology

Neuropsychology

Psychology

Social Work

Prosthetics/Orthotics

- A rehabilitation coordinator position in each region, to facilitate the links between all phases of rehabilitation.
- Long-term community support for people with an acquired brain injury.

Other recommendations included the identification of rural health sites that could provide rehabilitation programs locally, in collaboration with the community rehabilitation team.

While it was envisioned that the model would be implemented with separate teams in the three regions of the state, in practice there were inconsistencies across the state, with better provision of services in the south compared with the north and north-west (Milne & Eagar, 2007).

During the period of the present research—from January 2004 to December 2007—the following services were available:

5.2.3 Inpatient rehabilitation team.

Inpatient rehabilitation services were provided in three locations: the Royal Hobart Hospital (RHH) in southern Tasmania, the Launceston General Hospital (LGH) in the north of Tasmania and the North West Regional Hospital (NWRH) in the north-west of Tasmania. Tasmania had 50 beds dedicated for rehabilitation patients within these three major regional hospitals (12 per 100,000).

Neurosurgical services specific to acquired brain-injury were provided by a specialist neurosurgical unit, in the RHH. Following specialist treatment in the neurosurgical unit transfers to inpatient units for a period of rehabilitation was negotiated for each individual from the north of the state returning to the major regional hospitals. The LGH and the NWRH had dedicated rehabilitation inpatient facilities for adults.

The RHH had an inpatient rehabilitation ward that was primarily established to meet the needs of older people. During the period of this study, and for a number of years prior to it, this ward was responding to the needs of some people with an acquired brain injury or other complex conditions, by allocating them beds on this ward for their rehabilitation needs. Prior to this, some rehabilitation occurred on the busy neurosurgical ward despite the fact that it has an acute surgical focus.

5.2.4 Community rehabilitation team.

In southern Tasmania a multidisciplinary rehabilitation team was set up in Hobart in July 2003 at the Community Rehabilitation Unit (CRU), in response to the State-wide Strategic Plan (Department of Health and Human Services, 2003). However the model outlined above of a community multidisciplinary team providing services in the subacute phase of rehabilitation was not implemented in the north and north-eastern regions. Even in the south access to specialised services was variable: for example there was inadequate provision of specialist rehabilitation services such as motor vehicle driving assessment, and hydrotherapy. Staffing shortages at CRU impacted on service delivery, and during the course of this study these were compounded by budgetary constraints which restricted recruitment of staff, in 2006 and 2007 in particular. In the north and north-west, individuals who required rehabilitation in the community were given treatment by single disciplines as outpatients of the two regional hospitals. Some patients were referred to CRU for some services, such as neuropsychological assessment, which were not available at all in northern and north-western Tasmania.

5.2.5 Community services.

Community (non-acute) services in Tasmania were provided through a network of government and non-government service providers whose function was to provide ongoing skill development and maintenance management, as well as provision of primary care and referral to specialist services when required. These services included GPs, community nurses, allied health staff, home help and home maintenance staff, personal carers and providers of day services. Access to these services was provided through referral by rehabilitation and community allied health/nursing staff, self-referral by clients, or the individual's GP.

5.3 The Community Rehabilitation Unit (CRU)

A key component of the model of rehabilitation services described in the State-wide Strategic Plan for Rehabilitation Services in Tasmania is the community rehabilitation team in each region, providing services for all adults in the sub-acute and re-establishment phases of rehabilitation with strong linkages with the inpatient rehabilitation team on the one hand and with community services on the other.

During the period of the present study, the rehabilitation team at CRU was the single point of referral for all individuals who required access to public outpatient multidisciplinary rehabilitation in southern Tasmania. Because of lack of services in the north and north-west, some individuals were also referred from those regions to CRU. This was usually for neuropsychological assessments, but they were occasionally seen by other disciplines.

5.3.1 Referrals.

Referrals to CRU were received from medical and allied health professionals working in acute hospitals, from rehabilitation physicians, and from GPs and allied health professionals working in the community. Some referrals were also received from the private sector, particularly from the inpatient rehabilitation ward at St John's Hospital, which provided the majority of rehabilitation beds in the private system in southern Tasmania. Referrals were also received from research assistants working for the TNTR research project, although referral to rehabilitation services was not one of the aims of the project.

5.3.2 Intake.

Intake meetings took place twice a week and were attended by a senior clinician from each discipline, whenever possible. At these meetings all referrals were assessed for their appropriateness for the services of the multidisciplinary rehabilitation team and, if considered inappropriate were returned to the referral agent.

For the accepted referrals, an assessment was made about the disciplines to which the patient had been referred. Changes could be made by the clinicians present at the intake meeting. The patient was then assigned to one of five teams, depending on the consultant rehabilitation physician in charge of the case and/or the condition for which they have been referred. The teams were: spinal, neurological, amputee, orthopaedic and geriatric. TBI cases were usually assigned to the neurological team. A file was made up and a photocopy of the referral sent to each of the disciplines the individual was referred to. If that discipline had a waiting list the patient would be added to it. The first person in any discipline to see an incoming patient would conduct a screening interview, designed to make an initial assessment of their current condition and needs, and set goals for rehabilitation. Every patient assigned to more than one discipline was allocated for discussion at a case conference.

5.3.3 Case conferences.

Case conferences were held on a monthly basis for each team, except for the geriatric team which held them weekly, and all patients assigned to more than one discipline were discussed at them. Discussion of individual cases at the case conferences was based on perceived need, but would generally reduce in frequency over the period of rehabilitation.

When CRU began operating in 2003, case conferences were led by one of the specialist physicians, whenever possible. However, because their availability was variable, and this sometimes led to a lack of regularity in holding case conferences, this practice was gradually changed. By 2007 when the last referrals for the present sample were received at CRU, case conferences were usually led by senior allied health clinicians and were being held with greater frequency.

5.3.4 Rehabilitation coordinator.

This role was undertaken by a registered nurse with experience and tertiary qualifications in the field of rehabilitation. The rehabilitation coordinator provided an identifiable point of information and referral at CRU for both the acute inpatient and community-based services to liaise with. The person working in this position also provided clinical leadership, for the community rehabilitation team and for the discipline of rehabilitation nursing at CRU.

5.3.5 Specialist clinics.

Several of the RHH's specialist medical clinics had strong links with CRU, during the period of this study. These clinics were the rehabilitation clinic, the brain injury clinic, the multiple sclerosis clinic, the Parkinson's disease clinic, the spinal cord injuries clinic, the amputee clinic, the geriatric clinic and the falls clinic. Some of the clinics, including the brain injury clinic, were held on the same premises as CRU and were supported by its allied health and nursing staff. However these clinics were operated separately from CRU's multidisciplinary team and clinical notes were recorded in the RHH files, not the CRU clinical files, even for patients who were concurrently receiving treatment at CRU. Patients seen in the specialist clinics could be referred to CRU for input from its multidisciplinary team and 16 members of the sample in the current research were referred to CRU. After discharge a patient would often have a review appointment with one of the clinics and could be referred back for another episode of care at CRU if physicians believed that this would be beneficial. However, referral to the clinics could only be made by a medical practitioner so if allied health or nursing staff at CRU believed a review by a medical specialist was necessary or would be beneficial they requested the individual's GP to make this referral.

5.3.6 Specialist medical staff.

A number of specialist medical staff had involvement with patient care at CRU. During the period of the current research a consultant in rehabilitation medicine and a consultant geriatrician led the case conference discussions, whenever they were available to do so. The medical staff liaised with allied health professionals and nurses at CRU about treatment for individuals who had been seen in the specialist clinics and who were also referred to CRU, or already receiving treatment there. Nevertheless it is important to note that in the model of rehabilitation services described in the State-wide plan it was envisioned that specialist medical staff would be part of the multidisciplinary team operating at CRU and co-ordinated by its manager, but in practice the involvement of the specialist physicians in the service-delivery at CRU was variable. Case conference discussions were led by a consultant rehabilitation physician or one of the other specialist physicians when one was available, but with increasing frequency over the period of this research this role was passed to a senior allied health professional.

Additionally, patients receiving treatment at CRU could only be reviewed by a specialist medical practitioner at one of the specialist medical clinics and, as outlined above, referral to these clinics was only accepted from medical practitioners, not from allied health or nursing staff. This meant that if the rehabilitation team wanted a medical review for a patient, they had to request the patient's GP to make a referral to one of the specialist clinics. This could cause delay, or occasionally, if the GP chose not to make the referral, could prevent the patient being reviewed at all.

5.3.7 Manager.

The manager of the community rehabilitation team at CRU was an allied health professional who ensured the co-ordination of CRU's clinical services, managed the day-to-day running of the service, and oversaw CRU's operational and strategic directions.

5.3.8 Clinical disciplines.

Seven clinical disciplines were operating at CRU during the period of this research: Physiotherapy, Occupational Therapy, Psychology, Rehabilitation Nursing, Social Work, Speech Pathology and Dietetics. Physiotherapy, the largest of these disciplines, was run by eleven staff and the smallest discipline, Dietetics, was run by a single staff member working one-day a week. Four allied health assistants, two part-time and two full-time, also assisted in different aspects of therapy. CRU's model of care can be best described as outpatient rehabilitation provided in the community by a multidisciplinary team.

The table below gives details of numbers of staff members and total hours of work for each CRU discipline in 2007.

Table 5.1
Staff numbers and staff hours for all CRU disciplines

CRU Discipline	Number of Staff	Full-time Equivalents
Physiotherapy	11	6.34
Occupational Therapy	7	5.9
Psychology	3	2
Social Work	2 (+ 1 vacant)	1.58 (0.58)
Nursing	3	2
Speech Pathology	1 (+ 1 vacant)	1 (0.4)
Dietetics	1	0.2
Total	28 (30)	19.02 (20)

Fluctuations, due to staff shortages, in the services provided by each discipline took place during the period of this research. For example, no Speech Pathology services were available during the period from May 2005 to November 2006 due to CRU's inability to recruit staff during this period and Dietetics was unavailable from June 2007 to February 2008. Other disciplines were able to provide ongoing services but were also restricted at times in their service provision due to staff shortages. Psychology, also had a period of staff shortages in 2005, but this discipline increased its staff over the life of the project from one part-time psychologist in 2003 to two full-time equivalent staff in 2007.

The descriptions below of the services provided by CRU's six disciplines have been adapted from the State-wide Strategic Plan for Rehabilitation Services in Tasmania (Department of Health and Human Services, 2003).

5.3.8.1 Nursing.

Rehabilitation nurses perform comprehensive, ongoing assessment of people engaging in rehabilitation programs, including cognition, functional ability, self-esteem, motivation and ability to assess progress towards rehabilitation goals. They facilitate multidisciplinary meetings and family conferences and act in a liaison and counsellor role with patients and their families and carers.

During the course of the present research, the majority of TBI referrals to the discipline of nursing at CRU were processed by a nurse who had a particular interest in the care of TBI patients and assisted the specialist rehabilitation physicians in the brain injury clinic. This nurse acted on an informal basis in a case manager role for TBI patients in a number of ways. For mTBI, in particular, she was often their first point of contact with the service. She performed an initial comprehensive assessment with each patient, and on the basis of that assessment she provided education and support and, where necessary, a referral to additional CRU disciplines. Initial assessments frequently took place on home visits.

5.3.8.2 Physiotherapy.

The role of the physiotherapist is to assess, diagnose and treat disorders of human movement, with special emphasis on the neurological, musculoskeletal and cardiovascular systems.

During the course of this study, Physiotherapy was the largest clinical disciplines at CRU with the equivalent of six full-time staff. Physiotherapy programs at CRU were based on functional goals designed to facilitate a person's physical recovery and maximise their ability to reach optimal levels of function and independence.

5.3.8.3 Occupational therapy.

Occupational therapy works in the context a patient's stage of life and environment to promote health, wellbeing, independence and productivity. Occupational therapy is indicated where the person's health condition, possibly in association with physical, social or attitudinal barriers within the environment, limits the ability to carry out activities of everyday life and/or restricts the ability to participate in social, vocational or recreational activities. The aim of occupational therapy intervention is to increase the patient's engagement in self-care, productivity and leisure activities within the context of their social and physical environment, and to maximise their physical, cognitive, affective and spiritual functioning. Therapy may be provided individually or in group settings. Intervention includes assessment and program planning, education and training/retraining, remedial techniques, compensation strategies and environmental adaptation and discharge planning. Potential outcomes are that the person's self management, occupational skills, range of involvement and motivation are maximised, occupational dysfunction is minimised and they are reintegrated safely and effectively into their environment.

The discipline of Occupational Therapy was the second largest discipline at CRU in terms of both number of staff and staff hours. During the period of this study an art group and a woodwork group were run regularly and a number of TBI patients from the current study attended the art group.

5.3.8.4 Psychology.

Psychologists in rehabilitation settings assess, monitor, treat and assist in the management of a range of cognitive, behavioural and adjustment difficulties. Psychologists working in rehabilitation may specialise in either clinical psychology or neuropsychology.

Clinical psychologists specialise in the prevention, diagnosis and treatment of serious psychological difficulties, with the aim of helping rehabilitation patients, carers and rehabilitation teams to address their situation effectively and adaptively. Assessments and interventions may focus on adjustment difficulties, affective disorders, challenging behaviours, poor self-care, substance abuse, eating disorders, sleep disorders or other problems involving significant psychological disturbance. Where psychopathology cannot be managed in the rehabilitation setting, the clinical psychologist will assist in the identification of, and referral to, appropriate alternative service providers.

Clinical neuropsychologists provide specialist assessment and intervention for rehabilitation patients with known or suspected neurological disorders or acquired brain injury. Assessments may focus on diagnostic issues, cognitive strengths and weaknesses or competency issues. Clinical neuropsychologists document and provide feedback about their assessments to patients, families and treating teams, to assist the understanding and management of cognitive difficulties. Clinical neuropsychologists also assist in the design and implementation of cognitive behavioural management programs, compensatory strategies and in the provision of psychotherapeutic interventions to facilitate emotional adjustment, assist with return to work or study, and reintegration into the community.

When CRU was established in 2003 psychological services were largely confined to neuropsychological assessment provided by one staff member who worked one-day a week (0.2 FTE). In 2004 a part-time clinical psychologist was employed and the neuropsychology hours were increased. At that time neuropsychology was run by one part-time neuropsychologist performing neuropsychological assessments, giving feedback to patients and occasionally also providing cognitive rehabilitation. Clinical psychology was staffed by a part-time clinical psychologist performing assessment and clinical psychological interventions. In 2005 the two services, neuropsychology and clinical psychology, were joined into a single discipline providing neuropsychological assessment, cognitive rehabilitation and clinical interventions. Referral of a large number of participants to CRU, many of whom required psychological services, may have been a factor in the expansion of the service, which by 2007 employed two full-time staff.

5.3.8.5 Social work.

In rehabilitation, a patient’s need for social work service and the extent of the service are influenced by multiple factors. Key factors are the degree and extent of disability and lifestyle change; the degree and extent of personal, family and/or significant-other crisis reactions in response to the diagnosis, and the existence of non-health related personal, social or environmental problems or issues which negatively impact upon the patient or their family

Social work interventions in rehabilitation include counselling, crisis intervention, case management and discharge planning, service co-ordination, liaison, referral, resourcing, advocacy, and critical incident stress debriefing. They are provided to maximise the psychosocial functioning of the patient and their family and to ensure they have access to required support services. Furthermore, social workers liaise with the other disciplines to maximise the patient, and their family or significant-other's participation in rehabilitation and adjustment to disability and lifestyle change.

5.3.8.6 Speech pathology.

In the rehabilitation setting, speech pathologists are predominantly involved in service provision to the broad diagnostic category of neurology. The frequency and intensity of speech pathology intervention may vary greatly based on the neurological diagnoses serviced within a rehabilitation facility. Speech pathology intervention is appropriate for disorders of swallowing and feeding, communication, respiratory dysfunction, and cognition, including memory. Speech pathologists are active team members in the management of interactive complex issues for patients with neurological deficits.

During the course of the present research, speech pathology services at CRU were mostly provided by one full-time speech pathologist, although there was funding for an additional part-time speech pathologist. There was an extended interruption of speech pathology services from March 2005 until November 2006 due to a national shortage of speech pathologists in rural and regional areas.

5.3.8.7 Dietetics.

The dietician in community rehabilitation assesses a patient’s nutrition-related needs, draws up a nutrition care plan and gives advice on implementation. The primary aim of dietetic management in community rehabilitation is to promote normal nutritional status, thereby optimising functional status and reducing medical complication rates.

5.4 Summary and Research Directions

Over the past twenty years there has been a move away from a medical model of rehabilitation, which assumed a linear pathway from pathology through impairment to disability and on to handicap, towards a social model, which puts the responsibility back onto society to allow disabled individuals to function to the best of their ability. This is reflected in the World Health Organization's International Classification of Functioning, Disability and Health (ICF; World Health Organisation, 2001). Rehabilitation is the multi- and inter-disciplinary management of a disabled person's functioning and health. The goals of rehabilitation are to minimise symptoms and disability through a process of restoration of function or compensatory strategies. The rehabilitation process can be divided into stages: acute, sub-acute, post-acute and community maintenance. However following TBI, patients will have different requirements and each patient will have different needs at different stages of the rehabilitation process. Rehabilitation of TBI patients may be different from rehabilitation in general, due to the influence of specific problems, such as executive and memory deficits. Evidence and expert opinion suggest that rehabilitation is most effectively delivered by a coordinated team of professionals from relevant disciplines.

Rehabilitation services in Tasmania are funded by one of two models: private and public. Patients in the private sector are funded by compensable funds or private insurance. Services in the public sector are provided in the public health system by the DHHS, an agency of the Tasmanian State Government.

The 2003 State-wide Strategic Plan for Rehabilitation Services in Tasmania, in the public sector, addressed many of the recommendations for rehabilitation outlined in this chapter—for example the need for multidisciplinary teams in both acute and community settings with good coordination between them, the need for access to specialist medical and allied health services, and the need for provision of specialist services for patients with TBI. However implementation of these recommendations was inconsistent across the three regions of the state with better provision of services in the south compared with the north and north-west.

During the period of the present study, CRU was the single point of referral for all individuals who required access to public outpatient multidisciplinary rehabilitation in southern Tasmania, and for individuals in the north and north-west of the state needing input from a multidisciplinary out-patient rehabilitation team. Referrals to CRU were received from medical and allied health professionals working in acute hospitals, from rehabilitation physicians and from GPs and allied health professionals working in the community. During the period of the current research referrals were also accepted from the TNTR research project.

CRU’s clinical services can be best described as outpatient rehabilitation provided in the community by a multidisciplinary team. In multidisciplinary teams health professionals from different disciplines work alongside each other but not necessarily in close collaboration. Although it was envisioned in the State-wide Plan for Rehabilitation Services in Tasmania that specialist medical physicians would be part of CRU's multidisciplinary team, in practice this was not the case. A specialist physician led case conferences in 2003 when the service was set up, but by 2007, largely due to their unavailability, this role had been passed to a senior allied health clinician. Although some of the specialist clinics, including the brain injury clinic was held on the CRU premises, and was supported by CRU nursing and allied health staff, the clinics were run separately from CRU’s multidisciplinary team and clinical notes were recorded in the hospital filing system not the CRU clinical files, even for patients who were concurrently receiving treatment at CRU. Referral could be made from the clinics to CRU, but if allied health or nursing clinicians from CRU wanted a patient to be seen by a medical specialist, a referral to one of the clinics had to be made by the patient's GP. It could not be made by the rehabilitation team at CRU.

The outline of current developments in rehabilitation, and the specialist needs of TBI rehabilitation summarised in this chapter suggests that in developing a model of pathways of rehabilitation it will be important to consider the following factors:

- The ICF conceptual model of disability (World Health Organisation, 2001) provides an internationally accepted framework for consideration of the issues relevant to disability and rehabilitation.
- The objectives of rehabilitation are to maximise the injured individual's behavioural repertoire, optimise his or her environment and help with emotional stress in both the patient and significant others.
- Although rehabilitation can be thought of in terms of stages, different TBI patients will have different requirements, and the same patient will have different needs at different stages of the process.
- Specific problems, such as executive functioning and memory deficits pose unique challenges in TBI rehabilitation.
- Evidence and expert opinion suggest rehabilitation is most effectively delivered by a coordinated team of professionals with the expertise and skills to undertakes assessment and management of person with TBI at all levels of the ICF model;
- Good communication and coordination are essential at multiple levels.
- Although a multidisciplinary team approach to rehabilitation was advocated in the State-wide Plan for Rehabilitation Services for all three regions of Tasmania, in practice implementation of this plan was variable with better provision of services in the south compared with the north and north-west.
- Although it was envisioned that specialist medical staff would be part of the multidisciplinary team operating at CRU and co-ordinated by its manager, in practice specialist physicians had little involvement in service-delivery at CRU.
- Several specialist clinics, including a brain injury clinic, were operated on the same site as CRU and with support from its nursing and allied health staff, but did not constitute part of CRU's clinical service: clinical notes were recorded in the

RHH files not the CRU clinical files, even for patients who were concurrently receiving treatment at CRU.

CHAPTER 6 - Study 1: The Relationship Between Demographic, Injury-related and Post-injury Variables and Referral to Rehabilitation Services

Chapters 2, 3 and 4 of this thesis provide information about the definition and epidemiology of TBI, summarise research into predictors of outcome and review the nature and effectiveness of TBI rehabilitation. Chapter 5 gives information about rehabilitation services for TBI and an overview of rehabilitation services in Tasmania. The current chapter provides details of the methodology and results of the first study reported in this thesis. Study 1 describes the characteristics of the participants of the Tasmanian Neurotrauma Register (TNTR), an adult population-based, prospective traumatic brain injury outcome study located in Hobart the capital city of the Australian state of Tasmania, and investigates how those characteristics related to their referral or non-referral to post-acute rehabilitation services following their injury.

As described in chapters 2 and 3, TBI has been shown to be a leading cause of disability in adults, many of whom are young people with a normal life span ahead of them. Although more severe injuries have poorer outcomes overall, disabilities occur in a percentage of all injuries, irrespective of severity. A wide range of other factors have been shown to be related to poorer psychosocial outcomes following TBI. These include demographic factors (such as older age, female gender, lower IQ and lower education levels), injury related factors (such as previous TBI, violence-related injuries and hospitalisation), and post injury factors (including cognitive and functional disability, psychological distress and high levels of PCS). Routine follow-up, to assess rehabilitation needs, is recommended for all those with moderate and severe TBI, and provision of appropriate information and advice has been shown to be effective in reducing persisting symptoms and disability in mild injuries. However the literature indicates that many TBI sufferers, particularly those with mild and moderate injuries, receive no rehabilitation follow-up. Information about rehabilitation services in Australia is limited but national publications, and the studies that have been done, have suggested that compensable clients who access services in the private sector are better served than those whose health care is publically funded.

6.1 Aims and Hypotheses

The aims of the current study were to examine some demographic, injury-related, and post-injury characteristics of the participants of the Tasmanian Neurotrauma Register (TNTR) research project, and assess:

- which variables predict referral for rehabilitation;
- whether these variables differ according to the nature of the rehabilitation service (private or public), and
- for the group referred to public rehabilitation, whether these variables differ according to referral source.

Based on the research reviewed in chapter 3 of this thesis, it was hypothesised that:

- older participants would be more likely to be referred for rehabilitation.
- women would be more likely to be referred for rehabilitation.
- participants with lower education would be more likely to be referred for rehabilitation.
- participants with lower levels of estimated premorbid IQ would be more likely to be referred for rehabilitation.
- those with a history of TBI would be more likely to be referred for rehabilitation.

- participants with more severe injuries (PTA > 1 day) would be more likely to be referred for rehabilitation than those with mild injuries, but a proportion of those with mild injuries would also be referred.
- participants who were not functionally independent would be more likely to be referred for rehabilitation.
- participants with higher levels of disability would be more likely to be referred for rehabilitation.
- participants with higher levels of PCS would be more likely to be referred for rehabilitation.
- participants with higher levels of anxiety would be more likely to be referred for rehabilitation.
- participants with higher levels of depression would be more likely to be referred for rehabilitation.
- because a proportion of motor vehicle accidents would be compensable, the group referred in the private sector would contain a larger proportion of transport-related injuries than the groups referred to public rehabilitation services.
- because referrals by TNTR research assistants were made on the basis of a perceived gap in service provision, this group would have higher levels of PCS, pain, fatigue, anxiety and depression, than the other groups.

6.2 Method

6.2.1 Participants.

All participants for this study were individuals who had consented to be part of TNTR research project following a TBI. This project was funded from 2003 until 2008 by the Motor Accidents Insurance Board. The Motor Accidents Insurance Board is a Tasmanian Government business enterprise which gives medical and income benefits on a no-fault basis to persons injured in motor vehicle accidents, while enabling access to common law.

The TNTR commenced a population-based prospective TBI outcome study in December 2003. The project attempted to recruit all individuals over the age of 16, including those not admitted to hospital, who presented following a TBI to the ED at the RHH. Eligibility criteria for the TNTR outcome study included a period of loss of consciousness and/or loss of memory or transient confusion, and/or concussive symptoms following trauma involving the head.

Data for the present study were collected for all TNTR participants. For those who accessed public rehabilitation at the Community Rehabilitation Unit (CRU) some data were also collected there. CRU is a service of the Department of Health and Human Services which provides outpatient rehabilitation, and is the single point of referral for all adults in Tasmania who require access to public outpatient multidisciplinary rehabilitation services. A more detailed description of CRU's role in rehabilitation services in Tasmania, and the clinical services it provides is included in chapter 5 of this thesis.

The Human Research Ethics Committee (Tasmania) Network gave approval for the TNTR outcome study (Ref: H0007116) on 8th May 2003. An amendment to allow data collection at CRU was approved on 9th October 2006 and a further amendment related to the current study was approved on 24th September 2007. Documentation for the Human Research Ethics Committee (Tasmania) Network approval for the TNTR and the two amendments relating to this study can be found in Appendix A.

Participants for the present study were 1226 adults who had sustained a TBI and consented to participate in the TNTR outcome study. As can be seen from table 6.3, participants mean age-at-injury was 36.90 years (*SD* = 17.81), and ranged from 16 to 97, with a median of 32.07 years. Approximately two thirds (65%) of the sample was male, but this percentage varied according to age: the highest percentage was found in the sample between 20 and 40 years of age (73% male), and the lowest in the sample 60 years and above (49% male). Participants reported an average of 11.14 years of education (SD = 2.31), with a median of 10 years. These demographic characteristics are similar to TBI samples reported in epidemiological studies in adult samples in Australia (Hillier, et al., 1997; Tate, et al., 1998) and overseas (Kraus, et al., 1984).

Intellectual functioning prior to injury was estimated for more than two thirds of participants using the National Adult Reading Test (NART; Nelson, 1982) or, for individuals with reading difficulties, the Vocabulary subtest of the Wechsler Adult Intelligence Scale (WAIS III; Wechsler, 1996) and showed a normal distribution. Mean estimated pre-injury IQ was 97.71 (*SD* = 11.87), with a median of 99.00 and a range of 65 to 122. This variable was not available for all participants because of refusal to complete the NART by a proportion of participants, and the inability of others to complete the test, on grounds such as fatigue or difficulties with concentration.

Transport-related accidents (39%), assaults (27%) and falls (22%) accounted for the majority of injuries. More than two thirds (74%) of the participant group had PTA of 24 hours or less, putting them in the category of a mTBI according to the definition of the Mild Traumatic Brain Injury Committee of the Head Injury Inter-disciplinary

Special Interest Group of the the American Congress of Rehabilitation Medicine (ACRM) (Kay, 1993). Sixteen percent had suffered moderate injuries with a PTA of more than 24 hours but not greater than 7 days, and severe injuries with a PTA of more than 7 days accounted for 10% of the sample. Forty eight percent of the sample had been hospitalised followed their injury and 7%, reported having suffered a previous TBI.

The Australian Standard Classification of Occupations (ASCO) (McLennan, 1997) was used to classify participants according to their occupation at the time of injury. This classification system contains nine major groups, and an additional five categories were added to classify individuals who were not in paid employment. These additional categories were: student, retired, disability pension, unemployed and home duties. As shown in table 6.1 all of the groups were represented in the sample, although only half (51%) of the sample was in paid employment at the time of their injury. This is very similar to the percentage of employed participants (52%) reported in as study in South Australia by Hillier et al. (1997).

Table 6.1
Pre-injury Occupation Status for all TNTR Participants

Occupation Category	*n*	%	Cumulative %
Managers and Administrators	8	0.7	0.7
Professionals	62	5	6
Associate Professionals	71	6	12
Tradespersons and Related Workers	177	14	26
Advanced Clerical and Service Workers	9	0.7	27
Intermediate Clerical, Sales and Service Workers	97	8	35
Intermediate Production and Transport Workers	65	5	40
Elementary Clerical, Sales and Service Workers	60	5	45
Labourers and Related Workers	79	6	51
Student	153	13	64
Retired	137	11	75
Disability Pension	68	6	80
Unemployed	122	10	90
Home Duties	57	5	95
Unknown	61	5	100
Total	1226	100	

6.2.2 Design.

This study used a cross-sectional design, which sampled adults who had sustained a TBI and had agreed to participate in the TNTR outcome study. Data on all the variables examined in the study were collected as soon as possible following participants' injury and emergence from post-traumatic amnesia (PTA) to examine their relationship to their referral or non-referral to post-acute rehabilitation.

6.2.3 Instrumentation.

The following measures, all of which, with the exception of the pain and fatigue rating scales, have been described in more detail in chapter 3 of this thesis, were used in this study:

- **Rivermead Post-Concussion Symptoms Questionnaire** (RPQ; King, Crawford, Wenden, Moss, & Wade, 1994) is a measure of the severity of post-concussion symptoms (PCS).
- **Hospital Anxiety and Depression Scale** (HADS; Zigmond & Snaith, 1983) is a self-assessment scale, developed to assess levels of anxiety and depression in physically ill patients in inpatient and outpatient settings.
- **National Adult Reading Test** (NART; Nelson, 1982) is one of the most commonly used measures of estimated intelligence in English speaking patients with suspected intellectual deterioration.
- **Functional Independence Measure** (FIM; Corrigan, et al., 1997) is a well-researched measure of functional independence for use in TBI rehabilitation.
- **Disability Rating Scale** (DRS; Rappaport, et al., 1982) is a measure for assessing disability over the course of TBI recovery.
- **Pain Numeric Rating Scale** is an eleven point scale visual analogue scale (VAS) used for participants to rate their pain level at the time of assessment. "No pain" was rated as 0 and "most pain" was rated as 10. Rating scales have been shown to be an appropriate measure of the subjective experience of pain (Kenny, Trevorrow, Heard, & Faunce, 2006)
- **Fatigue Numeric Rating Scale** is an eleven point VAS scale used for participants to rate their fatugue level at the time of assessment. "No fatigue" was rated as 0 and "most fatigue" was rated as 10. Ratings scales have been

shown to be an appropriate method for subjective quantification of fatigue (Aaronson et al., 1999)

- **Controlled Oral Word Association Test (COWAT)**, also known as the FAS test, is test of verbal fluency, as measured by the ability to generate words beginning with a specific letter (Spreen & Strauss, 1998).
- **Trail Making Test (Test B)** is a measure of executive function, requiring the integration and processing of two series of simultaneously presented information (Strauss, et al., 2006).
- **Digit Span** is a measure of working memory from the Wechsler Adult Intelligence (WAIS III; Wechsler, 1996).
- **Digits Forward minus Backward** is a measure of the executive in working memory, obtained by subtracting the raw string length on the Digits Backward task from the string length on Digits Forward task of the Wechsler Intelligence Scales (Lezak, et al., 2004). It captures information which is lost when the scores are combined.
- **Information Processing Task** from the Adult Memory and Information Processing Battery (AMIPB; Coughlan & Hollows, 1985), is a test of information processing speed.

6.2.4 Procedure.

Staff at TNTR received a daily email from a clerk responsible for entering ICD-10 codes (World Health Organization, 1990), listing all persons who had presented over the previous 24 hours to the RHH's ED, with a code for TBI. Additionally, research assistants, including a registered nurse employed by TNTR, regularly checked patients on the neurosurgery, orthopaedic, and surgical wards to ensure that cases of

TBI who were hospitalised for other-system injuries were not overlooked, as has been shown to occur in other settings (Moss & Wade, 1996).

Research staff at TNTR initially interviewed these people on the wards of the RHH, or by telephone, if they had not been admitted to hospital or had been discharged. If a person’s eligibility for the project was confirmed during that interview, they were invited to participate in the research project. Details of the numbers of TBI patients invited to participate are displayed in table 6.2 together with those who refused, were not contactable, were prisoners, or had died.

Table 6.2
Details of TNTR Recruitment

	n		Cumulative %
Recruited to TNTR		1,226	51%
Unable to contact	516		23%
Refused	538		22%
Overseas	50		2%
Prisoners	33		1%
Deaths	19		1%
Sub Total	1,156	1,156	
Total		2,382	100%

All participants were provided with an Information Sheet and Consent Form (see Appendix B) and were given a full explanation of the nature and aims of the study, and the voluntary nature of their involvement. They were informed that they could withdraw from the project at any time, without prejudice to their future health care. If a potential participant was unconscious, consent was obtained from a relative until they regained consciousness and any period of PTA ended, at which time the procedure described above was followed. Participants confirmed their consent to take part in the study by signing the consent form. The consent form for all participants less than 18 years of age was signed by a parent or guardian.

Participants were seen for an initial assessment, as soon as possible after their TBI, and then invited to attend follow-up assessments at one-month, three-months, six-months, one-year, and then annually to a maximum of five-years post-injury.

PTA was assessed by subjective estimation at the first interview using a standard interview. For inpatients, the Westmead PTA Scale (Shores, et al., 1986) was administered by occupational therapists as part of the hospital's routine procedures, and the first interview was delayed until the participant had scored twelve out of twelve on three consecutive days, indicating the end of PTA.

Demographic and injury-related data were collected at the first assessment (median = 7 days), and tests and questionnaires assessing a range of cognitive, physical and psychosocial variables were completed at all assessments. The data reported in this study on psychological, physical and cognitive status were collected at each participant's first assessment at TNTR. At each assessment, all participants were asked about the medical and rehabilitation services they had accessed post-injury. Although referral to rehabilitation services was not one of the aims of the project, TNTR research assistants began to refer some participants for rehabilitation, to the Community Rehabilitation Unit (CRU), only a few weeks after the research project's inception, in response to what was perceived as a gap in services. As described in chapter 5, CRU is a service of the Tasmanian DHHS, which provides outpatient rehabilitation and is the single point of referral for all adults in Tasmania who require access to public outpatient multidisciplinary rehabilitation services. Other participants were referred to CRU by medical and allied health professionals independently from TNTR. A third group of participants accessed rehabilitation services in the private sector, while a large sample received no rehabilitation.

For the group referred for rehabilitation in the private sector information about the date of their referral was not collected. For those referred to CRU however this information was later collected from CRU clinical files: 65% were referred in the first three months post-injury and 90% in the first nine months.

For the purpose of this study the whole sample of TNTR participants was divided, according to rehabilitation status, into the following groups:

CRU-TNTR (*n* = 121)	- referred to CRU by TNTR research assistants
CRU-Other (*n* = 54)	- referred to CRU by hospital and community services
Private (*n* = 247)	- received rehabilitation in the private sector
No-Rehab (*n* = 804)	- no rehabilitation

The four groups were compared on the following variables:

Demographic variables

- Gender
- Age-at-injury
- Years of education
- Estimated pre-morbid IQ (NART, WAIS Vocab.)

Injury-related variables:

- Previous TBI
- Cause of TBI
- Severity of injury (PTA)
- Hospital admission following injury

Post-Injury physical variables:

- Post-concussion symptoms (RPQ)

- Pain (VAS)
- Fatigue (VAS)
- Functional independence (FIM)
- Disability (DRS)

Post-injury psychological variables:

- Anxiety (HADS anxiety scale)
- Depression (HADS depression scale)

Post-injury cognitive variables:

- Executive function (COWAT, Trails B, Digits F/B)
- Working memory (Digit Span)
- Information processing speed (AMIPB)

Employment status:

- Employed/Not employed

6.2.5 Analyses.

Differences between the four groups (CRU-TNTR, CRU-Other, Private and No-Rehab) on continuous variables listed were investigated using a one-way between groups analyses of variance (ANOVA), followed by Tukey post-hoc tests where appropriate.

For each dichotomous categorical variable, a global chi-square test was performed to determine whether, overall, there was a significant difference between the four groups. If this chi-square test was significant, post-hoc tests were performed between the six pairs to determine which pairs differed significantly on the variable in question—for example, percentages of hospitalised cases in each group. For cause of injury, analyses were performed using only the three main causes of injury (transport, assault and falls) which together accounted for 88% of cases. As the resulting variable had three categories, separate chi-square tests were performed comparing each category with all others causes combined, followed by pair-wise tests if the initial test was significant.

The results of this study, and all subsequent studies in this thesis, were analysed using the Statistical Package for the Social Sciences (SPSS). For *t*-tests, when Levine's test indicated that the assumption of homogeneity of variances had been violated, the alternative *t*-value was used, and Welch's procedure was used for ANOVAs in the same circumstances, as recommended by Tomarken and Serline (1986).

Because of the probability of finding one analysis in twenty significant due to chance, given the large number of analyses performed in this study (and also in subsequent ones reported in this thesis), a statistical significance of $p < .01$ was adopted.

Some data were missing on some of the variables in this and subsequent studies. This was due to the refusal or inability of a proportion of participants to complete some or all of the tests and questionnaires at TNTR, often due to the participant feeling unwell. Efforts were always made to continue the assessment at another time, but this was not always possible.

6.3 Results

The results of this study are presented in two sections. The first section gives further details of the demographic and injury-related characteristics of the whole sample; the second section looks at differences in the four groups characterised by rehabilitation status (CRU-TNTR, CRU-Other, Private, No-Rehab).

6.3.1 Demographic and injury-related characteristics of whole sample.

The demographic and injury-related characteristics of the whole sample are presented in table 6.3.

Estimation of pre-morbid intellectual functioning was obtained for two thirds of the sample, using the National Adult Reading Test (NART; Nelson, 1982) and, for a small percentage of individuals who had difficulty with word reading, the vocabulary subtest of the Wechsler Intellectual Scale (WAIS III; Wechsler, 1996). Demographic-predicted IQ estimates for cases with missing data were not used because of limitations identified in previous research (Langeluddecke & Lucas, 2004; Vanderploeg, Schinka, & Axelrod, 1996). The high proportion of individuals who were students, home-makers, or pensioners would also have been a practical limitation on the use of this method with this sample.

Assault was the second highest cause of injury accounting for 27% of the sample. This contrasts with reports of 8.2% of injuries caused by assault in a New South Wales study (Tate, et al., 1998) and 9% in one in South Australia (Hillier, et al., 1997). In Europe also, TBI caused by violence or assault is generally about 10% of reported cases (Tagliaferri, et al., 2006).

Table 6.3

Demographic and Injury-related Characteristics of the Whole Sample

Demographic Characteristics		Injury Characteristics	
Gender (*N* = 1226)		Previous TBI (*N* = 1192)	
Female	430 (35%)	No previous TBI	1105 (93%)
Male	796 (65%)	Previous TBI	87 (7%)
Age-at-injury (*N* = 1226)		Cause of TBI (*N* = 1216)	
Mean	36.90 (*SD*:17.81)	Transport	472 (39%)
Range	16 - 97	Assaults	335 (27%)
Median	32.07	Falls	264 (22%)
16-30 years	572 (47%)	Sporting	68 (5%)
31-59 years	500 (41%)	Other	77 (6%)
> 59 years	154 (13%)	Unknown	10 (1%)
Pre morbid IQ (*N* = 887)		PTA (*N* = 1174)	
Mean	97.71 (*SD*:11.87)	Mean	3.16 (*SD*:9.94)
Range	65 - 122	Range	0 - 180
Median	99	Median	.06
Low (< 90)	212 (24%)	≤ 1 hour	577 (49%)
Average (90-109)	530 (60%)	> 1 hr – 24 hrs	295 (25%)
High (> 109)	145 (16%)	> 24 hrs – 7 days	187 (16%)
		> 7 days	115 (10%)
Years of Education (*N* = 1181)		Hospitalisation (*N* = 1142)	
Mean	11.14 (*SD*:2.31)	Hospitalised	548 (48%)
Range	0 – 22	Not hospitalised	594 (52%)
Median	10		
Low (≤ 11 years)	750 (64%)		
High (>11 years)	431 (36%)		

6.3.2 Characteristics of rehabilitation groups.

A total of 422 individuals, 34% of the whole sample, were referred for rehabilitation. Over half (59%) were referred for rehabilitation in the private sector. A further 29% was referred by TNTR staff because of what they perceived as a gap in services, and only 13% were referred for rehabilitation in the public sector by hospital and community services. The majority (65%) of the latter group of referrals were from the acute hospital wards or from the inpatient rehabilitation ward. Sixteen cases (30%) were referred by the hospital's outpatient clinics and only three cases were referred by health professionals in the community.

Results of chi-square and ANOVA analyses of differences in the demographic, injury-related, physical, psychological and cognitive variables between the four groups (CRU-TNTR, CRU-Other, Private and No-Rehab) are presented below. Significant (p <.01) differences between the groups are displayed in the right hand column of each table. Differences which were approaching significance (p ≥.01 but < .05) are shown in brackets.

6.3.2.1 Gender.

As can be seen from table 6.4, no significant differences were found between the four groups on this variable.

Table 6.4
Comparison of Rehabilitation Groups for Gender

Percent Male (*n* = 796)		χ^2 (3) = 5.88	p =.118	Post-hoc Comparisons
CRU-TNTR (76)	63%			n.s.
CRU-Other (43)	80%			n.s.
Private (155)	63%			n.s.
No-Rehab (522)	65%			n.s.

6.3.2.2 Age-at- injury.

Overall the *F* value between the groups on this variable approached significance (p = .03), although post-hoc tests did not identify any significant difference between pairs of groups (table 6.5). When the groups were compared on the percentage of "older" participants (>30 years), the CRU-Other and Private groups had significantly greater proportions of participants in this category compared with the No-Rehab group.

Table 6.5
Comparison of Rehabilitation Groups for Age-at-injury

Referral Source (n = 1226)	M	SD	F = 2.99	p =.030	Post-hoc Comparisons
CRU-TNTR (121)	35.58	14.01			n.s.
CRU-Other (54)	40.19	17.07			n.s.
Private (247)	39.39	18.13			n.s.
No-Rehab (804)	36.11	18.20			n.s.

Percent > 30 years (n = 654)	χ^2 (3) = 17.08	***p* =.001**	Post-hoc Comparisons
CRU-TNTR (72)	60%		(v 4. χ^2 (1) = 4.42 , p =.036)
CRU-Other (37)	69%		v 4. χ^2 (1) = 7.51 , p =.006
Private (149)	60%		v 4, χ^2 (1) = 9.28 , p =.003
No-Rehab (396)	49%		(v 1. χ^2 (1) = 4.42 , p =.036) v 2. χ^2 (1) = 7.51, p =.006 v 3, χ^2 (1) = 9.28 , p =.003

Note. Between-group differences approaching significance ($p \geq .01$ but < .05) are shown in brackets.

6.3.2.3 Education.

As can be seen from table 6.6, no significant differences were found between the four groups when their mean years of education were compared via ANOVA. When the groups were compared on the percentage of participants who had not completed high school (≤11 years), the two groups referred to CRU for public rehabilitation had greater proportions of participants with less than twelve years of education, compared with those not referred. This difference was statistically significant for the CRU-TNTR group (p =.002), and was approaching significance for the CRU-Other group (p =.022).

Table 6.6
Comparison of Rehabilitation Groups for Years of Education

Referral Source (n = 1181)	M	SD	F = 1.76	p = .15	Post-hoc Comparisons
CRU-TNTR (119)	10.76	2.06			n.s.
CRU-Other (54)	10.83	3.03			n.s.
Private (234)	11.13	2.20			n.s.
No-Rehab (774)	11.22	2.31			n.s.

Percent ≤ 11 years ed. (n = 750)		χ^2 (3) = 14.30 (3)	**p <.003**	Post-hoc Comparisons
CRU-TNTR (89)	75%			v 4; χ^2 (1) = 9.33, p =.002
CRU-Other (41)	76%			(v 4; χ^2 (1) = 5.25, p =.022)
Private (154)	66%			n.s.
No-Rehab (466)	60%			v 1; χ^2 (1) = 9.33, p =.002 (v 2; χ^2 (1) = 5.25, p =.022)

Note. Between-group differences approaching significance ($p \geq .01$ but < .05) are shown in brackets.

6.3.2.4 Estimated premorbid IQ.

Results for estimated premorbid IQ are displayed in table 6.7. No significant results were found between the four groups on this variable.

Table 6.7
Comparison of Rehabilitation Groups for Estimated Premorbid IQ (NART/WAIS Vocab.)

Referral Source (n = 887)	M	SD	F = 2.13	p =.095	Post-hoc Comparisons
CRU-TNTR (86)	95.14	12.00			n.s.
CRU-Other (35)	100.31	12.46			n.s.
Private (184)	97.35	11.90			n.s.
No-Rehab (582)	98.05	11.77			n.s.

6.3.2.5 Previous TBI.

Table 6.8 shows there was an overall significant difference between the groups for previous head injury (p <.001), and also demonstrates that the CRU-TNTR group had the highest percentage (23%) of cases reporting a previous TBI, significantly more than both the Private and No-Rehab groups. The CU-Other group had 13% of cases reporting a previous TBI, which was approaching significance compared to the Private (p = .019) and No-Rehab (p = .020) groups.

Table 6.8
Comparison of Rehabilitation Groups for Previous TBI

Percent previous TBI (n = 87)		χ^2 (3) = 54.78	**p <.001**	Post-hoc Comparisons
CRU-TNTR (28)	23%			v 3; χ^2 (1) = 29.25, p <.001 v 4; χ^2 (1) = 46.92, p <.001
CRU-Other (7)	13%			(v 3; χ^2 (1) = 5.52, p =.019) (v 4; χ^2 (1) = 5.43, p =.020)
Private (11)	5%			v 1; χ^2 (1) = 29.25, p <.001 (v 2; χ^2 (1) = 5.52, p =.019)
No-Rehab (41)	5%			v 1; χ^2 (1) = 46.92, p <.001 (v 2; χ^2 (1) = 5.43, p =.020)

Note. Between-group differences approaching significance ($p \geq .01$ but < .05) are shown in brackets.

6.3.2.6 Cause of injury.

Comparison of the four groups for the three main causes of injury—transport-related, assault and falls—are presented in table 6.9 below. More than two thirds of the sample accessing rehabilitation in the private sector was injured in transport-related accidents, whereas only about one third of the other groups had injuries that were transport-related. The group referred to CRU by TNTR staff had a higher proportion of assaults than the other groups, although compared with the CRU-Other group this difference was only approaching significance (p =.015). The CRU-Other group had the highest percentage (35%) of fall-related TBI.

Table 6.9

Comparison of Rehabilitation Groups for Cause of Injury

				Post-hoc Comparisons
Percent Transport (n = 472)		χ^2 (3) = 151.49	***p* <.001**	Post-hoc Comparisons
CRU-TNTR (35)	29%			v 3; χ^2 (1) = 64.58, p <.001
CRU-Other (16)	30%			v 3; χ^2 (1) = 36.48, p <.001
Private (180)	73%			v 1; χ^2 (1) = 64.58, p <.001 v 2; χ^2 (1) = 36.48, p <.001 v 4; χ^2 (1) = 141.42, p <.001
No-Rehab (241)	30%			v 3; χ^2 (1) = 141.42, p <.001
Percent Assaults (n = 335)		χ^2 (3) = 88.38	***p* <.001**	Post-hoc Comparisons
CRU-TNTR (55)	46%			(v 2; χ^2 (1) = 5.96, p =.015) v 3; χ^2 (1) = 87.09, p <.001 v 4; χ^2 (1) = 8.69, p =.003
CRU-Other (14)	26%			(v 1; χ^2 (1) = 5.96, p =015) v 3; χ^2 (1) = 23.17, p <.001
Private (13)	5%			v 1; χ^2 (1) = 87.09, p <.001 v 2; χ^2 (1) = 23.17, p <.001 v 4; χ^2 (1) = 70,08, p <.001
No-Rehab (253)	32%			v 1; χ^2 (1) = 8.69, p =.003 v 3; χ^2 (1) = 70.08, p <.001
Percent Falls (n =264)		χ^2 (3) = 19.73	***p* <.001**	Post-hoc Comparisons
CRU-TNTR (23)	19%			(v 2; χ^2 (1) = 5.36, p =.021)
CRU-Other (19)	35%			(v 1; χ^2 (1) = 5.36, p =.021) v 3; χ^2 (1) = 15.56, p <.001
Private (32)	13%			v 2; χ^2 (1) = 15.56, p <.001 v 4; χ^2 (1) = 13.52, p <.001
No-Rehab (190)	24%			v 3; χ^2 (1) = 13.52, p <.001

Note. Between-group differences approaching significance ($p \geq$ .01 but < .05) are shown in brackets.

6.3.2.7 Injury-severity.

Table 6.10 shows that an ANOVA comparing the four groups on mean PTA was significant (*p* <.001). Post hoc analysis found that the CRU-TNTR and No Rehab groups did not differ significantly from each other, both having a PTA of less than two days. The other two groups had significantly higher (*p* <.001) mean PTA: close to one week for Private and two weeks for CRU-Other. However when the groups are compared on the percentage of mild injuries, using the definition of a mild injury (PTA ≤ 24 hours), the CRU-TNTR and Private groups were not significantly different from each other, while the CRU-Other group had only 24% mild injuries (significantly smaller than the other three groups) and the No Rehab group had 84% mild injuries (significantly higher than the other three groups).

Table 6.10

Comparison of Rehabilitation Groups by Days of PTA

Referral Source (n = 1174)	M	SD	F = 40.45	**p <.001**	Post-hoc Comparisons
CRU-TNTR (121)	1.94	3.89			v 2; p <.001 v 3; p <.001
CRU-Other (54)	13.60	16.45			v 1; p <.001 v 3; p <.001 v 4; p <.001
Private (234)	6.63	16.45			v 1; p <.001 v 2; p <.001 v 4; p <.001
No-Rehab (765)	1.55	5.80			v 2; p <.001 v 3; p <.001

Percent ≤1 day PTA (n = 872)		χ^2 (3) = 139.14	**p <.001**	Post-hoc Comparisons
CRU-TNTR (78)	65%			v 2; χ^2 (1) = 24.40, p <.001 v 4; χ^2 (1) = 25.52, p <.001
CRU-Other (13)	24%			v 1; χ^2 (1) = 24.40, p <.001 v 3; χ^2 (1) = 22.52, p <.001 v 4; χ^2 (1) = 111.81, p <.001
Private (140)	60%			v 2; χ^2 (1) = 22.52, p <.001 v 4; χ^2 (1) = 60.31, p <.001
No-Rehab (641)	84%			v 1; χ^2 (1) = 25.52, p <.001 v 3; χ^2 (1) = 60.31, p <.001 v 2; χ^2 (1) = 111.81, p <.001

6.3.2.8 Hospital admission.

There were significant differences in the proportions of hospitalised cases contained in the groups (p <.001). As shown in table 6.11, the CRU-TNTR (38%) and No-Rehab (40%) had the smallest percentages of hospitalised cases, and were not significantly different from each other on this variable. The CRU-Other with 87% hospitalised cases and the Private group with 70%, each differed significantly (p <.001) compared with the CRU-TNTR and No-Rehab groups.

Table 6.11
Comparisons of Rehabilitation Groups for Hospital Admission

Percent Hospitalised (n = 548)		χ^2 (3) = 100.50	***p* <.001**	Post-hoc Comparisons
CRU-TNTR (46)	38%			v 2; χ^2 (1) = 36.03, p <.001 v 3; χ^2 (1) = 32.99, p <.001
CRU-Other (47)	87%			v 1; χ^2 (1) = 36.03, p <.001 (v 3; χ^2 (1) = 6.67, p =.010) v 4; χ^2 (1) = 45.48, p <.001
Private (161)	70%			v 1; χ^2 (1) = 32.99, p <.001 (v 2; χ^2 (1) = 6.67, p =.010) v 4; χ^2 (1) = 62.47, p <.001
No-Rehab (294)	40%			v 2; χ^2 (1) = 45.48, p <.001 v 3; χ^2 (1) = 62.47, p <.001

Note. Between-group differences approaching significance ($p \geq$ .01 but < .05) are shown in brackets.

6.3.2.9 Post-concussion symptoms (RPQ).

An ANOVA comparing participants' ratings of PCS on the RPQ found a significant overall difference (F = 39.90, p <.001). As shown in table 612, post hoc analysis indicated that the group referred for rehabilitation by TNTR reported significantly more (p <.001) PCS than the other three groups, which did not differ significantly from each other on this measure.

Table 6.12
Comparisons of Rehabilitation Groups for Post-concussion Symptoms (RPQ)

Referral Source (n = 1143)	M	SD	F = 39.90	***p* <.001**	Post-hoc Comparisons
CRU-TNTR (119)	32.19	13.34			v 2; p <.001 v 3; p <.001 v 4; p <.001
CRU-Other (51)	19.65	14.77			v 1; p <.001
Private (222)	20.28	13.34			v 1; p <.001
No-Rehab (751)	18.23	12.63			v 1; p <.001

6.3.2.10 Pain (VAS).

An ANOVA comparing the four groups on participants' ratings of pain found a significant overall difference (F = 10.23, p <.001), with post hoc comparisons demonstrating that the TNTR group was reporting higher levels of pain compared to the other groups: this difference was significant compared with the CRU-Other (p = .009) and No-Rehab (p < .001) groups and was approaching significance (p = .024) compared with the Private group (table 6.13).

Table 6.13
Comparisons of Rehabilitation Groups for Pain (VAS)

Referral Source (*n* = 903)	*M*	*SD*	*F* = 10.23	***p* <.001**	Post-hoc Comparisons
CRU-TNTR (94)	4.76	2.98			v 2; *p* =.009 (v 3; *p* = 024) v 4; *p* <.001
CRU-Other (40)	3.10	2.86			v 1; *p* =.009
Private (180)	3.76	2.74			(v 1; *p* =.024)
No-Rehab (589)	3.15	2.74			v 1; *p* <.001

Note. Between-group differences approaching significance ($p \geq .01$ but < .05) are shown in brackets.

6.3.2.11 Fatigue (VAS).

An ANOVA comparing the four groups on participants' ratings of fatigue found a significant overall difference (p <.001), with post hoc comparisons demonstrating that the TNTR group had significantly higher mean scores compared to the three other groups: this difference was significant compared with the Private (p = .001) and No-Rehab (p < .001) groups and was approaching significance (p = .014) compared with the CRU-Other group (table 6.14).

Table 6.14
Comparisons of Rehabilitation Groups for Fatigue (VAS)

Referral Source (*n* = 994)	*M*	*SD*	*F* = 6.49	***p* <.001**	Post-hoc Comparisons
CRU-TNTR (99)	5.85	2.43			(v 2; *p* =.014) v 3; *p* =.001 v 4; *p* <.001
CRU-Other (44)	4.43	2.49			(v 1; *p* =.014)
Private (197)	4.63	2.60			v 1; *p* =.001
No-Rehab (656)	4.70	2.56			v 1; *p* <.001

Note. Between-group differences approaching significance ($p \geq .01$ but $< .05$) are shown in brackets.

6.3.2.12 Functional independence (FIM).

Mean scores on the FIM for the four groups, compared via ANOVA, were significantly different overall (p <.001). Post hoc analysis (table 6.15) demonstrated that while the CRU-Other and Private groups did not differ from each other, they did differ significantly (p <.001) from the CRU-TNTR and No-Rehab groups, which both had higher scores, indicating greater functional independence.

Table 6.15
Comparisons of Rehabilitation Groups for Functional Independence (FIM)

Referral Source (*n* = 1158)	*M*	*SD*	*F* = 20.65	***p* <.001**	Post-hoc Comparisons
CRU-TNTR (115)	122.22	5.93			v 2; *p* <.001 v 3; *p* <.001
CRU-Other (51)	111.29	25.01			v 1; *p* <.001 v 4; *p* <.001
Private (232)	114.03	21.54			v 1; *p* <.001 v 4; *p* <.001
No-Rehab (760)	121.49	12.70			v 2; *p* <.001 v 3; *p* <.001

6.3.2.13 Disability (DRS).

An ANOVA comparing mean scores on the DRS for the four groups found a significant overall difference (p <.001). Post hoc analysis (table 6.16) demonstrated that while the CRU-TNTR and No-Rehab groups did not differ from each other, they did differ significantly (*p* <.001) from the CRU-Other and Private groups, which both had higher scores, indicating greater disability.

Table 6.16
Comparisons of Rehabilitation Groups for Disability (DRS)

Referral Source (*n* = 1156)	*M*	*SD*	*F* = 32.58	***p* <.001**	Post-hoc Comparisons
CRU-TNTR (114)	2.18	2.01			v 2; *p* <.001 v 3; *p* <.001
CRU-Other (50)	4.64	4.53			v 1; *p* <.001 v 4; *p* <.001
Private (235)	3.94	4.37			v 1; *p* <.001 v 4; *p* <.001
No-Rehab (757)	1.82	2.97			v 1; *p* <.001 v 3; *p* <.001

6.3.2.14 Anxiety (HADS).

An ANOVA comparing participants' scores on the anxiety scale of the HADS found a significant overall difference (*p* <.001), with post hoc comparisons demonstrating that the TNTR group was reporting significantly higher levels of anxiety (*p* <.001) than the other three groups (table 6.17). Mean anxiety scores were significantly higher (*p* <.001) than mean scores for depression, for all the groups, except the CRU-Other group (See Appendix K).

Table 6.17
Comparisons of Rehabilitation Groups for Anxiety (HADS)

Referral Source (*n* = 1121)	*M*	*SD*	*F* = 35.07	***p* <.001**	Post-hoc Comparisons
CRU-TNTR (110)	12.22	5.25			v 2; *p* <.001 v 3; *p* <.001 v 4; *p* <.001
CRU-Other (49)	6.31	4.91			v 1; *p* <.001
Private (227)	7.49	4.80			v 1; *p* <.001
No-Rehab (737)	7.42	4.65			v 1; *p* <.001

6.3.2.15 Depression (HADS).

An ANOVA comparing participants' scores on the depression scale of the HADS found a significant overall difference (*p* <.001), with post hoc comparisons demonstrating that the TNTR group was reporting significantly higher levels of depression (*p* <.001) than the other three groups (table 6.18). Mean anxiety scores were significantly lower (*p* <.001) than mean scores for depression, for all the groups, except the CRU-Other group (see Appendix K).

Table 6.18
Comparisons of Rehabilitation Groups for Depression (HADS)

Referral Source (*n* = 1121)	*M*	*SD*	*F* = 29.35	***p* <.001**	Post-hoc Comparisons
CRU-TNTR (110)	8.82	4.91			v 2; *p* <.001 v 3; *p* <.001 v 4; *p* <.001
CRU-Other (49)	5.67	3.88			v 1; *p* <.001
Private (227)	5.27	4.40			v 1; *p* <.001
No-Rehab (737)	4.79	4.06			v 1; *p* <.001

6.3.2.16 Executive functioning (COWAT, Trails B, Digits F-B).

As can be seen from table 6.19, no significant differences were found between the four groups when percentile scores for two tests of executive functioning, COWAT and Trails B were compared via ANOVA. Mean scores ranged from the 24th to the 28th percentile for the Trails B test and between the 23rd and 26th percentile for the COWAT suggesting performance approximating the lower limit of average to below-average range for the majority of the sample on these tests. Further analysis of scores for the whole sample (see Appendix L) provided confirmation of this: sixty-two percent of the sample scored in the below-average range for Trails B and 61% were in the below-average range for the COWAT.

Mean string length scores for WAIS digits forward minus digits backward are also presented in table 6.19. Overall an ANOVA comparing the four groups found a significant difference (p =.001). The highest mean score, indicating larger discrepancies between two Digit Span tasks, was found in the CRU-Other group. Only 37 of the CRU-Other group completed this test, and this may partially account for the fact that post hoc tests did not detect a significant difference between this group’s score and the Private group, which had the lowest score. Although the post hoc tests indicated a significant difference (p <.001) between the Private group and the No-Rehab group, the range of mean scores across all the groups was not unusual. The mean differences reported in the WAIS III manual for age groups from 16 to 89 years of age ranged between 1.62 and 1.80 (Wechsler, 1996).

Table 6.19

Comparisons of Rehabilitation Groups for Executive Functioning

Trails B (*n* = 830)	*M*	*SD*	*F* = 2.17	*p* =.09	Post-hoc Comparisons
CRU-TNTR (77)	16.81	24.55			n.s.
CRU-Other (31)	20.32	27.33			n.s.
Private (160)	23.13	25.46			n.s.
No-Rehab (562)	24.91	28.35			n.s.
COWAT (*n* = 896)	***M***	***SD***	***F* = 1.82**	***p* =.14**	**Post-hoc Comparisons**
CRU-TNTR (83)	20.04	23.23			n.s.
CRU-Other (36)	25.14	27.09			n.s.
Private (178)	22.70	24.08			n.s.
No-Rehab (580)	25.96	25.58			n.s.
Digit Span F-B (*n* = 901)	***M***	***SD***	***F* = 5.46**	***p* =.001**	**Post-hoc Comparisons**
CRU-TNTR (88)	1.77	1.28			n.s.
CRU-Other (37)	2.03	1.34			n.s.
Private (180)	1.54	1.29			v 4; *p* <.001
No-Rehab (596)	1.97	1.29			v 3; *p* <.001

6.3.2.17 Working memory (Digit Span).

No significant differences were found between the four groups compared via ANOVA on scaled scores on the Digit Span subtest of the WAIS III. As can be seen from table 6.20 all four groups had a mean scaled score of approximately 9, suggesting average scores for most of the sample on this test. Further analysis of the distribution (see Appendix L) found that 60% of the whole sample scored in the average range, with scaled scores of 8 to 12, 29% was below-average (< 8), and 11% was above-average (> 12).

Table 6.20
Comparisons of Groups for Working Memory

Referral Source (*n* = 902)	*M*	*SD*	*F* = 1.60	*p* =.19	Post-hoc Comparisons
CRU-TNTR (88)	88	8.53			n.s.
CRU-Other (37)	37	9.05			n.s.
Private (181)	181	8.99			n.s.
No-Rehab (596)	596	9.20			n.s.

6.3.2.18 Information processing speed (AMIPB).

Percentile scores for the Information Processing Task of the AMIPB, adjusted for motor speed, are presented in table 6.21. Although the overall *F* score reached significance (p = .005), post hoc analyses only identified a difference between the Private and No-Rehab groups which was approaching statistical significance (p =.031). However, the mean scores were all within the average range. Further analysis of the distribution (see Appendix L) found that 45% of the whole sample scored in the average range, with scaled scores of 25 to 75, 38% was below-average (< 25) and 17% was above-average (> 75).

Table 6.21
Comparisons of Rehabilitation Groups for Information Processing Speed (AMIPB)

Referral Source (*n* = 809)	*M*	*SD*	*F* = 4.43	***p* =.005**	Post-hoc Comparisons
CRU-TNTR (78)	33.91	27.07			n.s.
CRU-Other (29)	32.90	28.41			n.s.
Private (160)	35.10	27.55			(v 4; *p* =.031)
No-Rehab (542)	42.36	30.15			(v 3; *p* =.031)

Note. Between-group differences approaching significance ($p \geq .01$ but < .05) are shown in brackets.

6.3.2.19 Unemployment.

The group referred for rehabilitation by TNTR had a significantly higher proportion of individuals who were unemployed (p <.001), compared with the Private and No-Rehab groups (p <.001) but did not differ significantly on this variable from the CRU-Other group, (table 6.22).

Table 6.22
Comparisons of Rehabilitation Groups by Unemployment Status

Percent unemployed (n = 122)		χ^2 (3) = 18.44	***p* <.001**	Post-hoc Comparisons
CRU-TNTR (26)	22%			v 3; χ^2 (1) = 14.34 , p <.001 v 4; χ^2 (1) = 14.89, p <.001
CRU-Other (6)	11%			n.s.
Private (18)	8%			v 1; χ^2 (1) = 14.34 , p <.001
No-Rehab (72)	10%			v 1; χ^2 (1) = 14.89, p <.001

In summary the findings for demographic, clinical, psychological and cognitive variables, and referral to rehabilitation services were:

- The TNTR sample was similar to recent epidemiological studies in Australia with respect to gender and age, but, it contained a larger proportion of non-hospitalised cases (52%), of moderate and severe injuries (26%), and assaults (27%), than has been reported in most epidemiological studies in Australia and overseas.
- Four hundred and twenty two participants (34 % of the whole sample), were referred for rehabilitation, over half in the private sector. A further 121 were referred by TNTR for public rehabilitation, and only 54 were referred for rehabilitation in the public sector by hospital and community services.
- No statistically significant differences were found between the groups referred for rehabilitation, for gender, and estimated pre-morbid IQ, and very few significant differences were found on the measures of cognitive functioning.
- The CRU-Other group (p = .006) and the Private group (p = .003) had larger proportions of participants over the age of 30 when compared with the No-Rehab group, 49% of whom were over 30 years.

- The two groups referred in the public sector had greater percentages of participants who had not completed high school compared to the other two groups. This difference was statistically significant (p = .002), for the CRU-TNTR group (75%) and approaching significance (p = .022) for the CRU-Other group (76%).
- The two groups referred in the public sector had greater percentages of participants who had a previous TBI compared to the other two groups. This difference was statistically significant (p<.001), for the CRU-TNTR group (23%) and approaching significance for the CRU-Other group (13%).
- The CRU-TNTR group had a significantly higher (p<.001) percentage of assault-related injuries (46%), compared to the other three groups, although in comparison to the CRU-Other group, which had 26% assault-related cases, this difference was only approaching significance (p =.015).
- The Private group had a significantly higher (p<.001) percentage of transport-related injuries (73%), compared to the other three groups.
- The CRU-Other group had the highest percentage of TBI resulting from a fall (35%). This was significant (p <.001) compared to Private group (13%) and approaching significance (p = .021) compared with the TNTR group (19%) but was not significant compared with the No-Rehab group (24%).
- On mean PTA, the CRU-TNTR and No Rehab groups did not differ significantly from each other, both having a PTA of less than two days. The other two groups had significantly higher mean PTA: close to one week for Private (p < .001) and two weeks for CRU-Other (p<.001).
- The percentage of mild injuries (PTA≤ 24 hours) was not significantly different in the CRU-TNTR (65%) and Private groups (60%), whereas the CRU-Other group

with 24% mild injuries and the No-Rehab group with 84% mild injuries, each differed significantly (*p* <.001) compared with the other three groups.

- The CRU-TNTR (38%) and No-Rehab (40%) had the smallest percentages of hospitalised cases. The CRU-Other with 87% hospitalised cases and the Private group with 70%, each differed significantly (*p* <.001) compared with the other three groups.
- Mean anxiety scores were significantly higher (*p*<.001) than mean depression scores, for all the groups, except the CRU-Other group.
- The CRU-TNTR group had significantly higher mean scores for PCS (*p*<.001), pain (*p*<.001) anxiety (*p*<.001) and depression (*p*<.001) and had a higher proportion (22%) of unemployed participants, compared with the other three groups, which did not differ significantly from each other on these variables.
- The CRU-TNTR group had significantly higher mean scores for fatigue compared with the three other groups: this difference was significant compared with the Private (*p* = .001) and No-Rehab (*p*<.001) groups and was approaching significance (*p* = .014) compared with the CRU-Other group.
- The CRU-TNTR and No-Rehab groups did not differ significantly from each other on the FIM and DRS, but they did differ significantly (*p* <.001) from the CRU-Other and Private groups, which both had lower scores on the FIM and higher scores on the DRS, indicating less functional independence and greater disability.
- While mean scores for working memory and information processing were in the average range, results on measures of executive functioning indicated some impairment for the whole sample in these areas, with mean scores on the COWAT

and Trails B in the lower average to below-average range, and more than 60% of the sample scoring below-average on these tests.

6.4 Discussion

Reviews of TBI epidemiology (for example Bruns Jr & Hauser, 2003; Tagliaferri, et al., 2006) have highlighted the difficulty of making comparisons between individual studies, because of differences in research methods and definitions. Nevertheless it is acknowledged that some general trends are universal: TBI occurs in approximately two men for every one woman and has a peak incidence in young adults. On these demographic characteristics of gender and age, the whole sample in the current study was similar to reports of TBI incidence in epidemiological studies from Australia and overseas. However the TNTR sample was different from epidemiological studies of TBI in a number of other ways: notably it contained a large proportion (52%) of non-hospitalised cases and had a higher proportion of assault-related TBI (27%) than is usually reported either in Australia or overseas.

TBI patients who are hospitalised following their injury constitute only a small proportion of TBI incidence. For example, a study of mTBI over a five-year period found only 16% of cases were treated in hospital (Fife, 1987). Other researchers have found incidence rates of 25% in mild to moderately injured samples (Sosin, et al., 1996). However, the majority of epidemiological studies of TBI include only patients who have been hospitalised following their injury: A review of twenty-three European reports included only two with non-hospitalised cases (Tagliaferri, et al., 2006). Recent Australian studies of TBI incidence (Hillier, et al., 1997; Tate, et al., 1998) have also used hospitalised cases. When studies do include data from ED contacts, they often fail to specifically distinguish TBI from superficial injuries to the head, where there is no injury to the brain (Jager, Weiss, Coben, & Pepe, 2000; Meerhoff, De Kruijk, Rutten, Leffers, & Twijnstra, 2000; Yates, Williams, Harris, Round, & Jenkins, 2006). This lack of information about non-hospitalised cases has been identified as a gap in the TBI epidemiological literature (National Institutes of Health, 1999).

The current study looked at an adult population-based sample, identified on the basis of the relevant ICD-10 codes in the ED of the general hospital serving the whole of southern Tasmania. Additionally, research assistants regularly checked the RHH neurosurgery, orthopaedic and surgical wards to ensure that cases of TBI hospitalised for other injuries were not overlooked, as has been shown to occur in other settings (Moss & Wade, 1996). This is arguably more representative of adult TBI, than studies which use only hospitalised cases. However it is important to bear in mind that the current study used different methods of recruitment to those typically employed in an epidemiological study. Epidemiological studies commonly use ICD codes or a review of hospital charts to identify all patients who meet their inclusion criteria. The current study used similar methods to identify individuals meeting its inclusion criteria, but because the purpose of the TNTR project was assessment of outcome, only those who gave informed consented were included. Consequently, a proportion of individuals who had sustained a TBI in Tasmania during the course of the study were not included. The proportion of cases enrolled (51%) was similar to the proportion (50%) researchers in Oxford in the UK (Wenden, et al., 1998b) estimated they were able to include in a register of patients who had sustained a head injury of any severity.

The sample was categorised using the Australian Standard Classification of Occupations (ASCO) (McLennan, 1997) according to their occupation at the time of injury. and an additional five categories (student, retired, disability pension, unemployed and home duties) were added to classify individuals who were not in paid employment. All categories of occupations were represented in the TNTR sample and the percentage of the sample in employment (51%) was very similar to the percentage of employed participants (52%) reported in a study in South Australia by Hillier et al. (1997).

As non-hospitalised cases are generally milder injuries, it might be expected that the large proportion of non-hospitalised cases in the current study would result in a larger proportion of injuries in the mild category than has been reported elsewhere. Surprisingly, the proportion of mild injuries (74% mild injuries) was less than that reported by Hillier et al. in South Australia (82% mild cases). Tate et al. (1998) in New South Wales report 62.6% mild injuries, but both this sample and the South Australian study classified injury-severity according to Russell and Smith (1961b), who define a mTBI as being one with PTA of up to one hour. The current study used the American Congress of Rehabilitation Medicine's (ACMR) (Kay, et al., 1993) definition of a mild injury as having PTA not greater than 24 hours. When the Australian samples are examined using the ACRM definition, 91% of the South Australian sample and 82.5% of the New South Wales would be considered mild injuries, compared to 74% in the current study.

One possible explanation for the greater proportion of moderate and severe injuries in the current study is that those with more severe injuries were more likely to consent to participation in it. This would be consistent with a study of recruitment bias (McCullagh & Feinstein, 2003) which found that mTBI patients who agreed to participate in outcome research had more severe injuries than those who refused participation. Interestingly, a study looking at the attrition rate of the TNTR sample (Langley, Johnson, Slatyer, Skilbeck, & Thomas, 2010) found that those with injuries of greater severity were more responsive to follow-up than milder injuries. The authors suggest that, in the absence of any well-coordinated rehabilitation follow-up for TBI in

Tasmania, participants at TNTR may have viewed their attendance as having some therapeutic value. This may help to explain the large proportion of more severe injuries in the current sample.

The current study also differed from the Australian epidemiological studies cited above, and from studies overseas (Kraus, et al., 1984; Tagliaferri, et al., 2006), in the proportion of cases it contained which were caused by an assault. Assault was the second highest cause of injury accounting for 27% of the sample. This contrasts with reports of 8.2% of injuries caused by assault in the New South Wales study, and 9% in the South Australian study. In Europe also, TBI caused by violence or assault is generally about 10% of reported cases (Tagliaferri, et al., 2006). One exception to this is a study in Glasgow (Thornhill, et al., 2000), a city in Scotland which reported 28% of cases caused by assault. Glasgow is a large city with a reputation for violent crime: for example, the 2009 census reports Glasgow's homicide rate per million as the highest of any city in Western Europe. It is therefore surprising that the present study from a small city, in a state of Australia classified as 90% rural (Department of Health and Aging, 1994), should find a similar incidence of violence-related TBI. One possible reason may be that the rate of assaults is increasing in Australia. A recent study in New South Wales (Moffatt & Poynton, 2006) reported a doubling in the rate of assault incidents reported, from 500 per 100,000 in the 1990s to over 1,000 per 100,000 in 2001. These researchers found that the rate of reporting had remained unchanged over this period, and the increase in assaults reported therefore reflected a genuine increase in incidence. Australian Bureau of Statistics figures also indicate that assault-related crime in Tasmania show an upward trend, from 2,569 in 1999 to 4,059 in 2007 (Australian Bureau of Statistics, 2008). Additionally, the most recent report of the Australian Health and Welfare (Helps, et al., 2008), looking at hospital separations due to TBI, also found a relatively high proportion of assaults in cases where TBI was the principal TBI (14%), and an even higher rate where TBI was an additional diagnosis (16%).

Another possibility is that those injured in assault-related TBI may have been less likely to be hospitalised than those injured by other causes. If this was correct, then the current study, which had a higher proportion of non-hospitalised cases than has generally been reported, would also have a higher proportion of assault-related injuries than other studies. Examination of hospitalisation by cause of injury in the current sample did reveal that the rate of hospitalisation was significantly lower (p <.001) for those injured in an assault, compared with those injured by other causes: only 23% of assault-related injuries were hospitalised, compared with 48% of falls and 71% of transport related injuries (see Appendix M for this analysis). It may therefore be that cases of TBI caused by assault are frequently not followed up by medical services, and therefore not generally included in studies reporting TBI incidence. Interestingly a concussion clinic in New Zealand for mTBI (Snell & Surgenor, 2006) found a higher-than-expected (20%) rate of cases referred were for assault-related TBI. Data on hospitalisation were not given in this study, but the fact that 57% were referred by GPs or hospital EDs, suggests that many cases referred may not have been hospitalised post-injury.

The question then arises; were the assault-related TBI cases milder injuries (than TBI cases with other aetiologies) and therefore seen as less need of hospitalisation and post-acute rehabilitation? This would be consistent with the New South Wales study (Tate, et al., 1998) which found a 10% incidence of assault in mild and moderate injuries, with no cases reported in the severe category. As shown in Appendix N, comparison of the mean PTA of the three main causes of TBI, assault, transport and falls, in the present study indicated that assault-related injuries did have the lowest injury-severity. However, although they were significantly milder than the transport-related injuries (p <.001), there was no statistically significant difference between PTA in TBI cases caused by an assault compared to those caused by a fall. The higher rate of hospitalisation in falls-related TBI compared with assault-related injuries may therefore be due to comorbid conditions, such as orthopaedic injuries, and not necessarily because of the injury to the brain. Epidemiological studies indicate that falls are more likely to occur in older TBI patients (Kraus, et al., 1984), who are more prone to fractures than younger people (Kannus, Niemi, Palvanen, & Parkkari, 1997).

While there were few significant differences between the four groups in this study on the cognitive tests, the whole sample showed impairment on some of the measures used. In particular, scores for the whole sample on two tests of executive-functioning, Trails B and the COWAT, indicated that the majority of participants scored in the below-average range. Mean scores on the information processing speed task of the AMIPB indicated less impairment on this task, but nevertheless, on this measure also, 38% were in the below-average range, compared with only 17% in the above-average range. The results of the current study are consistent with numerous investigations which have found that TBI is associated with cognitive impairments. For example in a prospective outcome study of 436 moderate and severe TBI participants Dikmen, Machamer, Winn and Temking (1995a) reported that the performance of the head-injured group had been shifted downwards by about 25 percentile points on a comprehensive battery of neuropsychological measures. However it is surprising that in the current study there were no significant differences between the groups on most of the cognitive measures: The TNTR referred group, and those not referred for rehabilitation, had significantly milder injuries and might be expected to perform better on these measures, than the other two groups, which both contained more severe injuries. Well-controlled studies in moderate to severe TBI, indicate that increased severity correlates clearly in a dose-response relationship with cognitive impairment (Dikmen, et al., 1995a; Schretlen & Shapiro, 2003).

It is however important to note that this study looks at impairment by comparing participants' results on the cognitive measures to average normative data for those measures. More meaningful data might be gathered by using other methods, such as considering each individuals z score on the measure of premorbid functioning in relation to their z score on each of the cognitive tests. Although no statistically significant between-group differences on the measures of premorbid functioning were found in this study, the groups were not exactly the same. For example there was a difference of 5 IQ points between the CRU-TNTR group, with the lowest mean scores (M = 95.14; SD = 12.00) and the CRU-Other group, which had the highest means score (M = 100.31; SD = 12.46). Differences that were present may have exerted some underlying influence, and this deserves further investigation, although it was outside the scope of the current research to do so.

Another possible explanation, for the lack of significant differences between the four groups on some of the cognitive measures, is the relatively large proportion of missing data on some of these measures in all the groups. For both inpatients and those who completed assessments at the TNTR, there were a substantial proportion of participants who were too unwell to complete some, or all, of the cognitive test battery. Efforts were always made to continue the assessment at another time, but in many cases this did not eventuate and, as can be seen from tables 6.19, 6.20 and 6.21 data are missing from 20% to 30% of cases on the cognitive tests in this study. In the case of tests which require the participant to be able to write or draw, a proportion of participants may have been unable to complete the test due to orthopaedic injuries or other physical limitations. Trails B and the Information Processing task of AMIPB, which require the participant to be able to draw a line or cross out numbers, had the highest percentage of missing data, particularly for those referred by hospital and community services: Data were missing for 43% of the CRU-Other group for Trails B and 46%, for the Information Processing Task. More than 80% of this group were hospitalised following their injury and some would have sustained orthopaedic injuries. It is likely that many participants who were unable or unwilling to complete the cognitive tests had more severe injuries than those who completed them. This bias in the available data on these measures might account for the lack of significant differences between the groups, which on a measure of severity (PTA) that was available for 96% of participants, were markedly different.

In contrast with results on measures of executive functioning, mean scores on the Digit Span subtest of the WAIS III were within the average range for all groups. Although memory is one of the commonest reported deficits following TBI, studies of working memory using Digit Span have been inconsistent, with some suggesting no impairment (Brooks, 1975), while others have found impairment only on the digits backward task (Brooks, 1976; Haut, et al., 1990). A review by Vakil (2005) suggests that tasks that require manipulation of stimuli, and as such probably tap the central executive component of working memory, are more sensitive to the effects of TBI than tasks such as digits forward that probably tap the phonological loop. Interestingly the digits forward minus backward task did suggest that the greatest impairment on this task was in the CRU-Other group, which was also the most severely injured, although data were available for only 37 participants from this group and the differences were not statistically significant. The digits forward minus backward task also discriminated between those referred in the private sector and those that did not receive rehabilitation, with the former performing better. This may seem surprising, given that the Private group had a mean PTA of six days. However 60% of the group had sustained only a mild injury. Additionally, rehabilitation for those referred in the private sector was on the basis of insurance status, for the overwhelming majority of cases, and may have been more independent of the sequelae of TBI, such as cognitive impairment. In contrast, referral to CRU was on the basis of medical assessment for the group referred by hospital and community services, and usually on the basis of reported PCS and perceived distress for those referred by the TNTR. It is also likely that, as suggested above, many of the group with missing data for this variable would have been those with more severe injuries, who were too unwell to perform cognitive tasks.

This study aimed to assess which variables predicted referral for rehabilitation, and it was hypothesised that those at risk of poorer outcomes would be more likely to be referred. Based on research reviewed in chapter 3, those who were considered at risk of poorer outcomes were participants who were older, female, had lower education and/or lower premorbid IQ, a history of previous TBI, more severe injuries, had been hospitalised post-injury, had higher levels of cognitive and functional disability and/or higher levels of PCS and psychological distress. Although violence-related aetiology has also been shown to be a risk factor for poor outcomes, it was not hypothesised that assault-related TBI would be associated with an increased likelihood of being referred for rehabilitation. This was because the relationship between cause of injury and referral is complicated by factors such as the high number of individuals injured in transport-related accidents, whose rehabilitation is funded by insurance, and the numbers of older people who are more likely to be injured in a fall. Based on the large body of research that indicates a proportion of mild injuries will experience poor outcomes, it was also hypothesised that a proportion of mTBI patients in the present sample would also be referred.

Overall the results of the current study found that none of the variables examined differentiated between the group not referred for rehabilitation and the rest of the sample. However there were significant differences between the groups on most of the variables, suggesting that referral to rehabilitation across the three groups was based on different criteria. The variables that were associated with referral to public rehabilitation by hospital and community services were older age, hospitalisation, increased injury-severity, fall-related injury, functional dependence and higher levels of disability. With the exception of fall-related injury, referral in the private system was also associated with these factors, but the most important referral criterion for this group was insurance status. Seventy three percent of its members had been injured in a transport-related accident and most of them would have been covered by third-party insurance. Referral by TNTR, on the other hand, was not associated with any of these variables; as hypothesised, it was associated with high levels of PCS, anxiety, depression, pain and fatigue. The TNTR-referred group also included a higher proportion of unemployed participants, assault-related cases and previous TBI, compared with the other three groups. Lower levels of education (less than high school) were associated with referral to public rehabilitation, by TNTR, but not to referral in the private sector, and there was also a very strong tendency for referrals to CRU from hospital and community services to have lower education (p = .022). Female gender and lower estimated premorbid IQ were not associated with referral in any of the groups.

Because high levels of PCS, anxiety, depression pain and fatigue have all been linked with poorer outcomes in TBI outcome studies (as reviewed in chapter 3), and follow-up, for TBI patients reporting high levels of them, is recommended in TBI rehabilitation guidelines (British Society of Rehabilitation Medicine & Royal College of Physicians, 2003; New Zealand Guidelines Group, 2006), it is surprising that these variables were not also associated with referral to public rehabilitation by hospital and community services. However no significant differences were found on these variables for the CRU-Other group, compared with those not referred for rehabilitation. One explanation for this finding is that no system was in place to routinely screen for PCS or psychological distress in TBI patients, either in ED or on the wards of the RHH. Some informal screening may have taken place in RHH outpatient clinics, but there were no guidelines in place to indicate that these factors should be measured in TBI patients, and high levels considered as a possible indicator of rehabilitation need.

In contrast, TBI patients seen at the TNTR research project were given a comprehensive battery of tests, designed to assess outcome. Each assessment at TNTR included tests of PCS (RPQ), anxiety and depression (HADS), pain and fatigue (VAS). Research assistants were therefore aware when a participant was reporting high levels of these symptoms, and it is likely that many of the TNTR referrals were made on this basis, although, because the project had not been set up to provide a clinical service, no protocol was in place to indicate who should be referred. Referrals were made on a case-by-case basis and were dependent on the clinical judgement of the research assistants, most of whom were provisionally registered psychologists studying for a post-graduate qualification in clinical psychology. As clinical psychologists specialise in the assessment and treatment of psychological disorders, it is likely that high levels of psychological distress in particular, would have been considered by the TNTR staff as important criteria for referral.

There were striking differences between the three referred groups for injury-severity: the CRU-Other group and Private group had a mean PTA of close to two-weeks and one-week respectively, whereas the TNTR group had an average PTA of less than two days. As summarised in chapter 3 of this thesis, in moderate to severe injuries, severity of injury is one of the most important predictors of outcome (Dikmen, et al., 1995a; Dikmen, et al., 1995b; Gordon, et al., 2006; Ownsworth & McKenna, 2004). In the present research, injury-severity appears to be an important criterion of referral to rehabilitation for those in the public sector, although a proportion (24%) of mild injuries were also referred. Some of these mild cases may, however, have been referred for comorbid injuries, such as orthopaedic injuries requiring input from services such as physiotherapy. Similarly a proportion of those with mild injuries in the Private group may have been referred for other injuries, as well as, or instead of, the TBI. The CRU-TNTR, which was predominantly composed of individuals with injuries in the mild category (65% had PTA ≤ 1day) would, however, have been referred for TBI-related difficulties because referral for other reasons was not within the scope of the project. Because a large body of research (reviewed in chapters 2 and 3) has found ongoing problems in 5% to 20% of mTBI cases, it was hypothesised that a proportion of those referred for rehabilitation in the current study would have suffered injuries categorised as mild. Nevertheless it is surprising that such a large proportion of those referred by TNTR were mild injuries. One explanation for this result may be the fact that a quarter of this group had a history of previous TBI: It may be that some of those with mild injuries had previously suffered a more serious TBI. Previous researchers (Ponsford, et al., 2000; Thornhill, et al., 2000) have found that those with a history of TBI report higher levels of PCS from subsequent TBIs, even if they are mild. Because referral from TNTR was associated with higher levels of PCS depression and anxiety, it may be that those with a previous TBI were reporting high levels of PCS and psychological distress and were more likely to be referred by the TNTR research assistants.

Another possible reason is that almost half (46%) of the TNTR referred group were injured in a violence-related TBI. As discussed above, assault-related TBI cases in the present sample were less likely to have been hospitalised than injuries from other causes, and, compared with those injured in a transport-related accident were more likely to be mild injuries. Without the presence of the TNTR research project it is unlikely that milder assault-related TBI cases would have been referred for rehabilitation. Nevertheless the large percentage of assault-related in the TNTR sample, together with the high levels of PCS, pain, fatigue, anxiety and depression reported by the members of it, are consistent with the many studies (for example Gerhart, et al., 2003; Wenden, et al., 1998b) which have found that worse outcomes are experienced in those injured in violence-related TBI.

As hypothesised, cause of injury also differed significantly across the other two rehabilitation groups. The Private group contained a large proportion of transport-related cases. This reflects the nature of this group, the majority of the members of which were covered by third-party insurance, for transport related injuries. The CRU-Other group contained the largest proportion of TBI resulting from a fall. Epidemiological studies (Kraus, et al., 1984; Thurman, Alverson, Dunn, Guerrero, & Sniezek, 1999) have indicated that TBI resulting from a fall is more likely to occur in older adults, many of whom would be of retirement age and therefore less likely to be covered by workers compensation or to have private insurance. They would therefore be more likely to be treated in the public system. It is therefore likely that a proportion of the fall-related cases would have spent time in hospital for orthopaedic injuries, and subsequently been referred to CRU for rehabilitation of these injuries and/or disabilities resulting from the TBI.

The results of the present study indicate that no pathway existed for milder, non-hospitalised cases to be referred for public rehabilitation in Tasmania. Although referral to rehabilitation services was not one of the aims of the TNTR outcome study, research assistants performing assessments and collecting data for the project began to refer participants to CRU in January 2004, only one month after its inception, in response to what was perceived as a gap in service provision. Over the course of three and a half years, a total of 121 individuals, 29% of the sample accessing rehabilitation, was referred to CRU in this way. Results of the current investigation indicate that this group was not significantly different from the group not referred for rehabilitation on measures of physical functioning (FIM), disability (DRS) or mean PTA. However the TNTR-referred sample was more likely to have been injured in violence-related TBI and more likely to have experienced a previous significant TBI than the other groups. The members of this group were less likely to have completed high school than the Private groups and No-Rehab groups. At the first assessment at TNTR they were more likely to report being unemployed and they scored higher on the RPQ, the anxiety and depression scales of the HADS and had significantly higher levels of pain and fatigue than the other three groups. Although all of these features have been linked with poorer outcomes following TBI (as reviewed in chapter 3), without the presence of the TNTR research project, it is likely that most of this group would not have been referred for rehabilitation because they had suffered milder injuries and/or were not hospitalised post-injury: 65% of the CRU-TNTR group were mild injuries and 62% had not been hospitalised.

Follow-up has been shown to be effective in reducing the disability of people with mTBI severe enough to be admitted to hospital and/or with PTA of greater than one hour (Wade, et al., 1997; Wade, et al., 1998). In particular brief interventions providing information and reassurance have been shown to be effective in preventing long-term symptoms in mild injuries (Alves, et al., 1993; Borg, et al., 2004). Nevertheless, education and reassurance about the symptoms of TBI were not being given to individuals presenting with a mild head injury to the ED of RHH during the period of the current research. TBI patients were, at best, given only a half-page information sheet (Appendix P) with instructions about what should be done in the first 24 hours following the injury, a recommendation to call their doctor or return to ED in the event of experiencing any of a number of symptoms listed on the sheet, and a suggestion that most cases should be followed up by their own doctor. This lack of provision of information and reassurance to TBI patients at the RHH's ED may be one reason why a large number of mildly injured participants in this study reported high levels of PCS, pain, fatigue and psychological distress, and consequently were referred to CRU for rehabilitation by the TNTR research assistants. A number of questions arise from this; did this group of mildly injured individuals with high levels of distress and PCS engage with rehabilitation services? Was the therapy they received different from that of other groups? These questions will be addressed in subsequent studies in this thesis.

It is also interesting to note the large proportion of TNTR participants with moderate and severe injuries who were not referred for rehabilitation. Research suggests that patients presenting acutely to hospital with moderate to severe injuries should be routinely followed up to assess their need for rehabilitation, and patients discharged from in-patient rehabilitation should have access to out-patient, or community-based services, appropriate to their needs (Thornhill, et al., 2000; Turner-Stokes, et al., 2005). In the present study however 15% of the No-Rehab group, 124 cases, had a PTA of more than one day. Analyses of this group (Appendix O) indicated that while a proportion had been hospitalised following their injury—and may have been assessed as not being in need of rehabilitation—41 individuals were not hospitalised, and despite having sustained a moderate or severe TBI were not referred to rehabilitation services. Similarly 43 individuals referred by CRU-TNTR had sustained a moderate to severe injury but were not referred for rehabilitation by hospital or community services. A significant proportion of this group (42%) had not been hospitalised and were therefore unlikely to have been assessed for their need for follow-up.

Over the over three-and-a-half years of this study, only 54 individuals, four percent of the whole sample, were referred for public rehabilitation by hospital and community medical services, compared with 242 individuals who accessed rehabilitation in the private sector. The majority of those referred for public rehabilitation by hospital and community services were hospitalised following their injury and referral was by hospital medical staff (46 cases). This group had the highest levels of disability and lowest levels of physical functioning. Information about the reason for their referral was not included in the current study, but given that one third of cases was as a result of a fall, it is likely that a percentage of referrals may have been for physiotherapy and occupational therapy following bone fractures as well as, or even instead of, rehabilitation for the TBI. This would make the group routinely referred to public rehabilitation, for TBI-related problems, even smaller.

In Australia there are currently no national guidelines available for the management of TBI, but follow-up for these patients is recommended in guidelines developed in UK and New Zealand (British Society of Rehabilitation Medicine & Royal College of Physicians, 2003; New Zealand Guidelines Group, 2006). Little information is available about referral rates for public TBI patients in Australia but the very small number of participants referred for public rehabilitation by hospital and community services in the current study, and the large number of moderate and severe cases (124) who were not referred for any rehabilitation, suggest that routine follow-up was not occurring in Tasmania for TBI patients in the public sector during the course of this study.

The results of the current study confirm previous research (O'Callaghan, et al., 2009) that funding is a significant factor in access to rehabilitation services in Australia. The Private group constituted the largest proportion (58%) of rehabilitation cases, with almost three quarters of cases injured in transport-related accidents. The high prevalence of transport-related injuries in this group is probably due to medical and rehabilitation costs of the majority being paid by third-party insurance, as these individuals are invariably treated in the private sector. The remaining members of the Private group may be workers compensation cases and individuals with private health insurance, although specific information about this is not currently available. The Private group did not differ significantly from those referred to CRU by hospital and community services in its levels of disability and lowered physical functioning. It did differ in injury-severity, however. The mean PTA of the Private group was significantly higher than the CRU-TNTR group but it was lower than the CRU-Other group, and as mentioned above, it had a high proportion of mild injuries. Given that injury-severity was significantly associated with referral from the public sector, this group of mildly injured individuals may not have been referred for rehabilitation, if they had not been covered by private or third-party insurance.

Female gender which has been associated with poorer outcomes, particularly higher levels of PCS, in some studies (Farace & Alves, 2000) was not a factor in referral to rehabilitation in the current study. Study 2 will examine the relationship of gender and other demographic variables and engagement with rehabilitation services in those participants referred to CRU for rehabilitation in the public sector. Lower IQ, which in a limited number of studies has been shown to be associated with poorer outcomes, was also not associated with referral to rehabilitation in the current study. One reasons for this finding may be that data were missing on this variable for approximately one third of the sample, for reasons which are outlined in the "method" section.

6.4.1 Limitations.

In the interpretation of this study's results its limitations must be noted. Firstly, for some participants data were missing on some variables, which may have introduced a bias in some of the results. While for previous TBI, PTA, hospitalisation, education, measures of anxiety and depression, and PCS information was available for over 90% of participants, other variables, such as measures of cognitive functioning, IQ, and ratings of pain and fatigue, had higher proportions of missing data. The principal reasons for this 20%-30% missing data on some variables was some participants being too unwell to complete some tests and questionnaires at the initial assessment at TNTR. In particular they were more likely to refuse the cognitive tests, which were more taxing than the collection of demographic and injury-related data.

Secondly, information on participants history of previous TBI may be more complete for the groups referred to CRU (CRU-TNTR and CRU-Other) because, in some cases, information was obtained on this variable from the referral form, or in correspondence in the CRU clinical files. However the TNTR project accessed information from all participants' medical files and if a history of previous TBI was recorded this was entered into the data base, so this would only apply to cases where information was missing in the medical records.

Another limitation of the current study is that the TBI sample described may not be representative of the whole population of TBI patients in Tasmania, because it contains only those patients who were contactable and who agreed to participate in the TNTR research project. Details of those who refused consent, were not contactable, were prisoners, or had died are given in table 6.2. Although this may have introduced a bias into the current research, it is important to note that the inclusion of non-hospitalised cases does makes it more representative of TBI in Australia than studies which only include hospitalised cases. In common with TBI research overseas, recent Australian studies (for example Hillier, et al., 1997; Tate, et al., 1998) consider only hospitalised cases, thereby creating an estimate of the incidence of TBI admitted to hospital, rather than an estimate of the incidence of TBI treated by hospitals.

6.4.2 Summary and research directions.

This first study has examined the characteristics of the participants of the TNTR outcome research and found that, despite containing a large proportion of non-hospitalised cases, this sample had a larger proportion of moderate and severe cases than samples in recent Australian epidemiological studies. This may be due, in part, to a selection bias whereby those with more severe injuries or more PCS were more likely to consent to the study than those with milder injuries. The current sample also had much higher levels of assault-related-injuries than most epidemiological studies, possibly because of the inclusion of non-hospitalised cases. One third of the whole sample was referred for rehabilitation, with the majority accessing this in the private sector as a result of transport-related injuries, the medical costs of which were funded by third-party or private insurance. Two thirds of those who accessed public rehabilitation were referred by the TNTR research project itself. This group was not significantly different from the group not receiving rehabilitation on percentage of hospitalised cases, mean PTA, disability and functional independence. However its members were reporting more PCS, pain, fatigue, anxiety and depression, and had more assault-related injuries, more unemployment and a greater percentage of previous TBI than all of the other groups. The small sample referred by hospital and community medical services had the most severe injuries, the highest percentage of fall-related TBI, the highest proportion of hospitalised cases and reported more disability and lower levels of physical functioning than the other groups. They were also significantly older than those not referred. Violent aetiology and previous TBI, which have been shown to be predictors of poorer outcomes in previous research, were not associated with referral by hospital and community medical services. Lower levels of education (less than high school) were associated with referral to public, but not to private, rehabilitation. Although cognitive measures failed to discriminate between the different groups, the majority of the sample scored in the below-average range on measures of executive functioning. Mean scores on an information processing task suggested less impairment in this area, and the majority of the total sample were in the average range on a measure of working memory.

Fifteen percent of those who received no rehabilitation had sustained a moderate or severe TBI, suggesting that routine follow-up of more severe cases to assess rehabilitation needs was not occurring in Tasmania at this time. Although routine follow-up for moderate to severe TBI is recommended in the literature, and in guidelines for the management of TBI, only four per cent of the whole sample was referred for public rehabilitation by hospital or community services. Subsequent studies in this thesis will focus on this group, and those referred by the TNTR, to the Community Rehabilitation Unit (CRU), and will follow their progress in rehabilitation. Studies 2, 3 and 4 will consider how a range of demographic, injury-related and post-injury variables were related to their initial contact with CRU's clinical services. Because data were not available for many of those with more severe injuries on the cognitive measures, and the measures of pain and fatigue, reported in the current study, these variables will not be examined in subsequent studies. Study 4 which looks at post-injury variables will use the FIM as a measure of functioning and disability rather than the DRS, because of the DRS's relative insensitivity in mild injuries (Hammond, et al., 2004).

Some questions which arise from this first study are:

- Did the group of mildly injured individuals with high levels of psychological distress and PCS referred to CRU by TNTR engage with rehabilitation services?
- Was the therapy received by those who had suffered mild injuries different either in its amount or its nature, compared with moderately or severely injured participants?

The first question will be partially addressed in study 3, the results of which are reported in chapter 8 of this thesis, while study 5, which examines the amount and nature of therapy participants received at CRU, will look at the first question further and also address the second question. The results of study 5 are reported in chapter 10.

In developing a model of pathways of rehabilitation, which is one of the overall aims of the current research, the results of study 1 suggest it will be important to note the following factors:

- When non-hospitalised cases are included, assault-related TBI may be higher than many epidemiological studies suggest.
- The current study confirms previous research which suggests that funding is a significant factor in access to rehabilitation.
- TBI patients presenting to the ED of the RHH who were not hospitalised, were give only a one-page information sheet with basic information about what should be done in the first 24 hours following the injury.
- Routine follow-up to assess rehabilitation needs was not occurring in Tasmania, even for moderate to severe injuries.
- Referral to community rehabilitation in the public sector was largely confined to hospitalised cases and/or injuries at the moderate to severe end of the spectrum.
- No pathway existed in Tasmania for non-hospitalised TBI patients with high levels of PCS and/or psychological symptoms to access rehabilitation services in the public sector.

CHAPTER 7 - Study 2: The Relationship Between Demographic Variables and Initial Contact with CRU's Clinical Services

Study 1 outlined the characteristics of the participants of the Tasmanian Neurotrauma Register (TNTR), an adult population-based prospective TBI outcome study and investigated how those characteristics relate to their referral or non-referral to rehabilitation services following their injury. The next three chapters look at the two groups (CRU-TNTR and CRU-Other) referred to the Community Rehabilitation Unit (CRU) for post-acute rehabilitation in the community, and considers how a range of demographic, injury-related and post-injury variables were related to their initial contact with CRU's clinical services. Study 2, described in this chapter, considers how the demographic variables of age-at-injury, gender, premorbid IQ and years of education were related to the sample's referral to CRU's seven clinical disciplines. A discussion of the research that has looked at these variables, and their relationship with outcome after TBI has been outlined in chapter 3 of this thesis, and is briefly summarised below.

Older individuals have been shown to experience poorer psychosocial, cognitive, functional and employment outcomes, and age has been shown to be an independent predictor of outcome following TBI of all severities. Individuals who have not completed high school have lower levels of return to productivity following moderate to severe TBI, and lower levels of education are associated with poorer cognitive and functional outcomes in TBI of all severities. Few studies report outcome following TBI separately by gender, but the research that does exist suggests that some outcomes, particularly PCS, may be worse in women than men. Pre-morbid IQ is also frequently not reported in TBI outcome research but the studies reviewed in chapter 3, provides some support for an association with lower IQ and poorer outcomes following TBI.

Also of relevance to the present study, and to others reported in this thesis, is a small body of research in the area of service use post-TBI. This literature, reviewed in chapter 5, suggests that the amount and type of rehabilitation services individuals use may be influenced by a number of variables, such as services available locally, injury-severity and length of time since injury. Three studies, two in USA (High Jr, et al., 1995; Phillips, et al., 2004) and one in Australia (Hodgkinson, et al., 2000), document service utilisation after TBI. Although the Australian study found that neuropsychology was the allied health service most frequently accessed in the first two years post injury, all three studies found that "traditional" rehabilitation services, such as physiotherapy and occupational therapy, were accessed much more frequently than clinical psychology and counselling. In addition, High Jr et al., looking at variables affecting utilisation in four regional TBI rehabilitation centres in USA found that individuals with more years of education were more likely to use counselling services, whereas less educated individuals accessed case management more frequently. Women were also more likely to use counselling services than men.

7.1 Aims and Hypotheses

The present study aimed to examine the demographic characteristics of the sample referred to CRU and its seven clinical disciplines, and look at how they impacted on the probability of their being offered an appointment in those disciplines and, for the cohort who were offered appointments, the probability of their attending them. The relationship between these demographic variables and service utilisation, as measured by the number of disciplines participants were referred to, was also examined.

Based on the research reviewed in chapters 3 and 5 of this thesis and summarised above it was hypothesised that:

- Older participants would be referred to more CRU disciplines.
- Participants with lower education would be referred to more CRU disciplines.
- Participants with lower estimated premorbid IQ would be referred to more CRU disciplines.
- Women would be more likely than men to access the disciplines of Nursing for assistance with PCS, and Psychology for cognitive symptoms and mood disturbance.
- Participants with higher levels of education would be more likely to access Psychology for counselling services, than those with less education.
- Participants with lower education would be more likely to be referred to the disciplines of Nursing and Social work, (which have more of a case management role at CRU than other disciplines) than those with higher education.

7.2 Method

7.2.1 Participants.

All participants for this study were individuals who had consented to be part of the Tasmanian Neurotrauma Register (TNTR) research project following a TBI. Details of this project are outlined in study 1 in chapter 6.

Eligibility criteria for the present study were individuals on the TNTR who were referred for rehabilitation at CRU for their TBI, and whose treatment in rehabilitation was provided by CRU clinicians. A description of CRU's role in rehabilitation services in Tasmania, and the clinical services it provides, is included in chapter 5.

A total of 180 individuals fitted these selection criteria. Out of this number, five individuals were excluded from the study: four because their referral was for hydrotherapy only and one because he had moved from the state. Hydrotherapy is one of the services offered by Physiotherapy at CRU but this service was managed by the community physiotherapy service for an extended period of time until 2007. Data were therefore unavailable for the majority of participants who were referred to this service and, for this reason, the four participants referred only for this service were therefore excluded from this study. This left a total of 175 individuals who were referred to CRU for rehabilitation following a TBI over a three and a half year period from January 2004 to May 2007. As can be seen from table 7.1 almost three quarters (74%) were referred within the first six months post-injury.

Table 7.1
Time of Referral in Relation to Injury for Whole Sample

Time post-injury	*n*	%	Cumulative %
Within 3 months	110	63	63
> 3- to 6 months	20	11	74
> 6 to 12 months	32	18	93
> 12 - 18 months	5	3	95
> 18 months to 24 months	4	2	98
> 24 months	4	2	100
Total	175	100	

The demographic characteristics of the sample are outlined in table 7.2. The percentage of males was marginally greater in this sub-sample compared to the whole TNTR sample described in study 1 of this thesis (68% versus 65%) and, although the mean age was similar, there were more participants in the 31 to 59 years of age bracket

(53% versus 41%). There was a wide range of years of education (0 to 22 years): one reason for this was that one participant reported receiving no schooling at all. The percentage of participants in the "low" education bracket (≤ 11 years) was greater in this sub-sample (75% compared with 64%). Data for estimated premorbid intellectual functioning was available for only two thirds (69%) of the sample for reasons outlined in study 1 in chapter 6 of this thesis.

Table 7.2
Demographic Characteristics of the Whole Sample

Gender (*N* = 175)		Years of Education (*N* = 173)	
Female	56 (32%)	Mean	10.78 (*SD*:2.39)
Male	119 (68%)	Range	0 – 22
		Median	10
		Low (≤ 11 years)	130 (75%)
		High (> 11 years)	43 (25%)
Age-at-injury (*N* = 175)		**Pre morbid IQ (*N* = 121)**	
Mean	37.00 (*SD*:15.12)	Mean	96.64 (*SD*:12.31)
Range	16 – 87	Range	65 – 121
Median	34.82	Median	97
16-30 years	66 (38%)	Low IQ (< 100)	67 (55%)
31-59 years	92 (53%)	High IQ (≥ 100)	54 (45%)
> 59 years	17 (10%)		

The Australian Standard Classification of Occupants (ASCO; McLennan, 1997) was used to classify participants according to their occupation at the time of injury. As outlined in study 1, an additional five categories were added to classify individuals who were not in paid employment. Occupation status for the 175 participants of this study is shown in table 7.3. As can be seen only 46% was in paid employment at the time of their injury. This compares with 51% of the whole TNTR sample described in study 1.

Table 7.3
Pre-injury Occupation Status for all Participants

Occupation Category	*n*	%	Cumulative %
Managers & administrators	1	1	1
Professionals	6	3	4
Associate professionals	8	5	9
Tradesperson	27	15	24
Intermediate clerical, sales & service	9	5	29
Intermediate production & transport	7	4	33
Elementary clerical, sales & service	5	3	36
labourers & related workers	17	10	46
Student	14	8	54
Retired	13	7	61
Disability pension	24	14	75
Unemployed	32	18	93
Home duties	12	7	100
Total	175	100	

7.2.2 Clinical Disciplines.

Seven clinical disciplines were operating at CRU during the period of this study: Nursing, Physiotherapy, Occupational Therapy, Social Work, Psychology, Speech Pathology and Dietetics.

In 2004 when the first referrals for the current study were received psychological services at CRU were divided into clinical psychology and neuropsychology, and these two services were run independently. Neuropsychology was run by one neuropsychologist performing neuropsychological assessments, giving feedback to clients and occasionally also providing cognitive rehabilitation. Clinical Psychology was staffed by a part-time clinical psychologist performing assessments and providing psychological interventions. In 2005 the two services were amalgamated into a single discipline providing neuropsychological assessment, cognitive rehabilitation; and clinical assessment and interventions. For this reason data for early referrals to the two separate services have been combined for the purposes of this study It is not therefore possible to indicate the percentage of participants referred for neuropsychological assessment and the percentage referred for clinical psychology. However it is possible to report how many neuropsychological assessments were performed. Forty four participants of the current research (32% of the sample) attended a neuropsychological assessment. As some referred may have failed to attend the number actually referred for this service may be higher than this.

During the period of the study there were fluctuations in the service provided by some disciplines, due to staff shortages. For example, in Speech Pathology staff shortages caused the cessation of service from May 2005 to November 2006. Staffing changes in Psychology in 2005 also caused a reduction in service for a number of months in 2005. When a referral was received for clinical or neuropsychological services during this time a letter was sent advising the referral agent of this delay, and in some cases suggesting alternative service providers.

More information about CRU's clinical disciplines and the services they were providing is outlined in chapter 5 of this thesis.

7.2.3 Design.

This study used a cross-sectional design, with adults who had sustained a TBI and had been referred for rehabilitation to CRU. Data on the variables of gender, age-at-injury, years of education, and estimated premorbid IQ were collected as soon as possible following participants' injury and emergence from post-traumatic amnesia (PTA), to investigate their role in relation to referral for rehabilitation and initial contact with CRU's clinical services. Information about participants' referral to CRU and to its clinical disciplines was obtained from CRU clinical files.

7.2.4 Procedure.

Participants' clinical files at CRU were examined to identify the date of all referrals made to clinical disciplines. For each of the disciplines involved in a participant's care the following information was also collected:

- The date of the first contact with the participant, either by telephone or letter
- The date of the first appointment offered to the participant
- The date of the participant's first attendance at an appointment or home visit (HV) with a clinician from that discipline,
- The number of home visits (HV)

Other information was also collected for use in subsequent studies, the details of which are included in the relevant study. In addition, the following data for each participant was obtained from assessments performed at TNTR:

- Gender
- Age-at-injury
- Years of education
- Estimated premorbid intellectual functioning (IQ) scores (obtained from administration of the NART or the Vocabulary subtest of the WAIS III)

Participants were divided in to two groups for each variable as follows.

Gender	Female / Male
Age-at-injury	"Younger" (16—30 years) / "Older" (> 30 years)
Education	"Low" (≤ 11 years) / "High" (> 11 years)
Premorbid IQ	"Low" (< 100) / "High" (≥100)

7.2.5 Analyses.

Chi-square analyses were used to explore the impact of the variables of gender, age-at-injury, years of education and estimated premorbid IQ by comparing the percentage of participants referred to ≤ 2 disciplines with the percentage referred to > 2 disciplines, for each variable. Chi-square analyses were also used to explore the impact of the same variables on referral to CRU's five largest disciplines, Nursing, Psychology, Physiotherapy, Occupational Therapy and Social Work, on the likelihood of participants being offered an appointment or HV in each of those disciplines and, for those who were offered one, on the likelihood of their attending it. These tests were not performed for the disciplines of Speech Pathology and Dietetics, because of the small samples referred to these disciplines. In this, and subsequent studies reported in this thesis, for analyses where the overall sample size was less than 40 or any one cell had an expected frequency of less than 3, chi-square analyses were not used, as recommended by McPherson (1990). Fishers Exact Test was used in these cases.

7.3 Results

The results of this study are presented in two sections. The first section looks at service utilisation, as measured by the number of clinical disciplines participants were referred to, and considers how the demographic variables of gender, age-at-injury, years of education and estimated pre-morbid IQ are related to it. The second section looks at how these demographic variables relate to participants' referral to each of the CRU clinical disciplines, to the probability of their being offered an appointment or home visit (HV) in a discipline and to the probability of their attending an appointment/receiving a home visit if offered one.

7.3.1 Referrals to CRU clinical disciplines.

As described in chapter 4 of this thesis, referrals to CRU were received from a number of sources and processed in twice-weekly intake meeting attended by a senior clinician from each discipline, whenever possible. For those referrals that were accepted as appropriate for the services of the multidisciplinary team at CRU, an assessment was made about the disciplines the patient was to be assigned to. As the information given on the referral form was an important factor in this decision, it was decided, in the present study, to see if there were significant differences, in the pattern of referral to CRU's clinical disciplines for those referred by TNTR, compared with those referred from other sources. This analysis is presented in table 7.4, below. As can be seen, significant differences were found in referrals to Nursing, Physiotherapy and Occupational Therapy. A larger proportion of the group referred to CRU by hospital and community services (CRU-Other) were subsequently referred to the disciplines of Physiotherapy and Occupational Therapy compared with the sample referred to CRU by the TNTR research project. On the other hand, more than 90% of the group referred to CRU by TNTR were subsequently referred to the discipline of Nursing, compared with only 72% of those referred by hospital and community services.

Table 7.4
Referrals to Separate Disciplines by Referral Source

	Nursing	Psychology	Physiotherapy	Occupational Therapy	Social Work
Referrals	n = 152	n = 137	n = 58	n = 50	n = 45
CRU-TNTR	93%	82%	24%	15%	27%
CRU-Other	72%	70%	54%	59%	22%
χ^2	14.65	2.88	14.90	36.03	.50
p	<.001	.09	<.001	<.001	.48

Table 7.5 displays the percentage of the samples referred to each of CRU's disciplines. Two individuals received no internal referral despite the fact that their referral to CRU had been accepted by the service. This may have been due to an administrative error as no clinical reason was apparent from their files. The majority of participants were referred to two or three disciplines.

Table 7.5
Number of CRU Disciplines To Which Participants Were Referred

Disciplines Referred to	Nursing	Psych.	Physio.	O.T.	Social Work	Speech Pathology	Dietetics
None *n* = 2 (1%)							
One *n* = 32 (18%)	18 (12%)	11 (8%)	2 (4%)			1 (8%)	
Two *n* = 58 (33%)	57 (38%)	51 (37%)	1 (2%)	3 (6%)	3 (7%)	1 (8%)	
Three *n* = 44 (25%)	39 (26%)	38 (28%)	22 (38%)	15 (30%)	18 (40%)		
Four *n* = 23 (13%)	22 (14%)	21 (15%)	18 (31%)	16 (32%)	11 (24%)	3 (25%)	1 (25%)
Five *n* = 10 (6%)	10 (6%)	10 (7%)	9 (15%)	10 (20%)	7 (16%)	2 (17%)	2 (50%)
Six *n* = 6 (3%)	6 (4%)	6 (4%)	6 (10%)	6 (12%)	6 (13%)	5 (42%)	1 (25%)
Total 175 (100%)	152 (100%)	137 (100%)	58 (100%)	50 (100%)	45 (100%)	12 (100%)	4 (100%)

Table 7.6 displays the results of chi-square analyses of study variables on service utilisation, as measured by the number of disciplines participants were referred

to: No significant differences were found. However, there was a trend towards those older than 30 years being referred to more disciplines, which failed to reach statistical significance (p = .049).

Table 7.6
Effect of Gender, Age, Education and IQ (NART/WAIS Vocab.) on Service Utilisation

	Referral to > 2 disciplines	*n*	$\chi 2$	*df*	*p*
Gender (*n* = 175)					
Female	46%	26	0.03	1	.86
Male	48%	57			
Age (*n* = 175)					
16-30 yrs	38%	25	3.88	1	.049
> 30 yrs	53%	58			
Education (*n* = 173)					
≤ 11 yrs	49%	63	0.05	1	.82
> 11 yrs	47%	20			
IQ (*n* = 121)					
< 100	42%	28	2.27	1	.13
≥ 100	56%	30			

7.3.2 Initial contact with clinical disciplines.

Table 7.7 shows the number and percentage of the sample referred to each discipline, the number and percentage of referrals given an appointment, or home visit (HV), by each discipline, and the number and percentage of those offered one who attended an appointment or received a HV.

HVs were conducted in the disciplines of Nursing, Social Work, Occupational Therapy and Psychology. Initial face-to-face contact with 32 of the sample referred to Nursing was in a HV, while 41 were first seen at CRU. Five of those referred to Social Work were seen in their homes and 13 only attended appointments at CRU. Three of those referred to Occupational Therapy and four of those referred to Psychology received a HV. Most of the HVs in disciplines other than Nursing were during the course of therapy, and not for the purpose of an initial assessment.

Table 7.7
Referrals, Appointments and Attendances for Separate CRU Disciplines

	Referral	Appt/HV offered	Appt/HV attended
Nursing	152 (87%)	83 (55%)	73 (88%)
Psychology	137 (78%)	109 (80%)	85 (78%)
Physiotherapy	58 (33%)	51 (88%)	42 (82%)
Occupational Therapy	50 (29%)	33 (66%)	25 (76%)
Social Work	45 (26%)	26 (58%)	18 (69%)
Speech Pathology	12 (7%)	8 (67%)	6 (75%)
Dietetics	4 (2%)	4 (100%)	3 (75%)

For five of the seven disciplines, chi-square tests were used to compare the groups referred to each discipline, those offered an appointment or HV and those who attended appointments on the demographic variables of gender, age-at-injury, years of education and estimated premorbid IQ. Due to the small numbers in the samples referred to Speech Pathology and Dietetics these analyses were not performed for these disciplines. The results of these analyses are presented below:

7.3.2.1 Gender.

Chi-square analyses for gender are presented in table 7.8. As can be seen from this table, no significant differences were found in the gender ratio of referrals to the different disciplines and the samples that were offered appointments and attended appointments. There was however, a tendency for Nursing to offer more appointment to women (p = .020).

7.3.2.2 Age-at-injury.

Table 7.9 gives chi-square analyses for age-at-injury for each of the disciplines. The results indicated that those above 30 years of age were more likely to be referred to Physiotherapy (p = .009) and, although not statistically significant, there were tendencies for Physiotherapy to offer more appointments to those in the older group (p = .051) and for those in the older age group to be referred to Occupational Therapy (p =.043).

7.3.2.3 Years of education.

Table 7.10 gives chi-square analyses for years of education for each of the disciplines. The results indicated that there was a trend towards participants with more than 11 years of education being referred to Physiotherapy more frequently than those with less education. (p = .037). However appointments in Physiotherapy were significantly (p = .005) associated with lower education.

7.3.2.4 Premorbid IQ.

Participants' premorbid IQ was estimated using the NART or the Vocabulary subtest from the WAIS-III during assessments at TNTR and was available for 121 of the whole sample. Reasons why data on this variable are missing for some participants are outlined in study 1 in chapter 5. Chi-square analyses for premorbid IQ are presented in table 7.11. As can be seen from this table, the only significant difference was in the discipline of Physiotherapy. Those with higher IQ were more likely to be referred for Physiotherapy than those with IQ less than 100 (p = .001).

The following is a summary of some of the demographic characteristics of the samples referred to each discipline:

7.3.2.5 Nursing.

The majority (87%) of the sample was referred to Nursing. Fifty four percent of those referred were offered an appointment or HV and 88% attended appointments or HVs. There were no statistically significant differences on demographic variables in referrals for Nursing, but there was a tendency to offer more appointments/HVs to women compared to men (p = .020)

7.3.2.6 Psychology.

A large percentage (78%) of participants was referred to Psychology. Eighty percent of those referred were offered an appointment and 78% of those offered appointments attended them. No significant differences were found on any of the demographic variables for referrals, appointments offered or attended in Psychology.

7.3.2.7 Physiotherapy.

One third of the sample was referred to Physiotherapy. Eighty eight percent of those referred were offered appointments and 82% of those offered an appointment attended it. Those above 30 years of age and those with higher IQ were more likely to be referred to Physiotherapy than those who were younger or who had lower IQ, with these differences reaching statistical significance at p = .009 and p =.001 levels respectively. There was a trend (p = .037) towards participants with higher education (> 11 years) being referred to Physiotherapy, but those with fewer years of education were more likely to be offered an appointment (p = .005). No other significant differences were found on any of the demographic variables examined in this study for appointments offered or attended in Physiotherapy.

7.3.2.8 Occupational therapy.

Twenty nine percent of the sample was referred to Occupational Therapy. Sixty-six percent of those referred were offered appointments and 76% of those offered an appointment attended it. There was a tendency for those above 30 years of age to be referred to Occupational Therapy more often than who were younger than 30 (p = .043). No significant differences were found on any of the demographic variables examined in this study for appointments offered or attended in Occupational Therapy.

7.3.2.9 Social work.

Twenty six percent of the sample was referred to Social Work. Fifty eight percent of those referred were offered an appointment or home visit in Social Work and 69% of those offered an appointment or home visit attended it. No significant differences were found on any of the demographic variables for referrals, appointments offered or attended in Social Work.

7.3.2.10 Speech pathology.

Only twelve participants (7% of the sample) were referred to Speech Pathology. Eight individuals were offered appointments and six attended them. These numbers were too small for statistical analysis.

7.3.2.11 Dietetics.

Only four participants (2% of the whole sample) were referred to Dietetics. All four were offered appointments and three individuals attended them. These numbers were too small for statistical analysis.

Table 7.8

Gender Information for Separate Disciplines

	Total Sample	Nursing	Psychology	Physiotherapy	Occupational Therapy	Social Work	Speech Pathology	Dietetics
Referrals	*N* = 175	*n* = 152	*n* = 137	*n* = 58	*n* =50	*n* = 45	*n* = 12	*n* = 4
Female	56 (32%)	89%	77%	32%	27%	29%	9%	2%
Male	119 (68%)	86%	79%	34%	29%	24%	6%	3%
χ^2 (*df*)		0.43 (1)	0.11 (1)	0.04 (1)	0.13 (1)	0.35 (1)		
p		.51	.74	.85	.72	.55		
Appointments		*n* = 83	*n* = 109	*n* = 51 [a]	*n* = 33	*n* = 26	*n* = 8	*n* = 4
Female		68%	86%	89%	73%	50%	80%	100%
Male		48%	77%	88%	63%	62%	58%	100%
χ^2 (*df*)		5.39 (1)	1.62 (1)		.51 (1)	0.62 (1)		
p		.020	.20	1.00	.47	.43		
Attendances		*n* = 73	*n* = 85	*n* = 42 [a]	*n* = 25 [a]	*n* = 18 [a]	*n* = 6	*n* = 3
Female		88%	73%	94%	73%	63%	100%	100%
Male		88%	81%	77%	77%	72%	50%	67%
χ^2 (*df*)		0.04 (1)	.82 (1)					
p		.95	.37	.24	1.00	1.00		

Note. [a] Fishers Exact test was used, in accordance with (McPherson, 1990) because *n* < 40 or at least one cell has an expected count <3.

Table 7.9
Age-at-injury Information for Separate Disciplines

	Total Sample	Nursing	Psychology	Physiotherapy	Occupational Therapy	Social Work	Speech Pathology	Dietetics
Referrals	*N* = 175	*n* = 152	*n* = 137	*n* = 58	*n* =50	*n* = 45	*n* = 12	*n* = 4
16 – 30 years	66 (38%)	91%	80%	21%	20%	21%	5%	2%
> 30 years	109 (62%)	84%	77%	40%	34%	28%	8%	3%
χ^2 (*df*)		1.52 (1)	.25 (1)	6.81 (1)	4.09 (1)	1.12 (1)		
p		.22	.62	**.009**	.043	.29		
Appointments/HV		*n* = 83	*n* = 109	*n* = 51 [a]	*n* = 33	*n* = 26	*n* = 8	*n* = 4
16 – 30 years		47%	77%	71%	54%	43%	33%	100%
> 30 years		60%	81%	93%	70%	65%	78%	100%
χ^2 (*df*)		2.52 (1)	.26 (1)		1.16 (1)	1.86 (1)		
p		.11	.61	.051	.28	.17		
Attendances/HV		*n* = 73	*n* = 85	*n* = 42 [a]	*n* = 25 [a]	*n* = 18 [a]	*n* = 6	*n* = 3
16 – 30 years		89%	71%	80%	57%	50%	100%	100%
> 30 years		87%	82%	83%	81%	75%	72%	67%
χ^2 (*df*)		.07 (1)	2.01 (1)					
p		.79	.16	1.00	.32	.33		

Note. [a] Fishers Exact test was used, in accordance with McPherson (1990), because *n* < 40 or at least one cell has an expected count < 3.

Table 7.10

Years of Education Information for Separate Disciplines

	Total Sample	Nursing	Psychology	Physiotherapy	Occupational Therapy	Social Work	Speech Pathology	Dietetics
Referrals	*N* = 175	*n* = 150	*n* = 136	*n* = 58	*n* =50	*n* = 45	*n* = 12	*n* = 4
Low ≤ 11 years	130 (74%)	88%	82%	29%	28%	29%	6%	3%
High > 11 years	43 (25%)	84%	70%	47%	33%	16%	9%	0%
χ^2 (*df*)		.44 (1)	2.66 (1)	4.33 (1)	.37 (1)	2.81 (1)		
p		.51	.10	.037	.54	.09		
Appointments/HV		*n* = 82	*n* = 108	*n* = 51 [a]	*n* = 33	*n* = 26	*n* = 8	*n* = 4
Low ≤ 11 years		54%	82%	97%	69%	52%	62%	100%
High > 11 years		56%	70%	70%	57%	86%	75%	0%
χ^2 (*df*)		.90 (1)	2.09 (1)		.68 (1)	1.99 (1)		
p		.55	.15	**.005**	.41	.10		
Attendances/HV		*n* = 72	*n* = 85	*n* = 42	*n* = 25	*n* = 18	*n* = 6	*n* = 3
Low ≤ 11 years		90%	76%	84%	76%	60%	60%	75%
High > 11 years		80%	91%	79%	75%	100%	100%	0%
χ^2 (*df*)		1.51 (1)	2.16 (1)	0.19 (1)				
p		.22	.14	.66	1.00 [a]	.13 [a]		

Note. [a] Fishers Exact test was used, in accordance with McPherson (1990), because *n* < 40 or at least one cell has an expected count < 3.

Table 7.11

Information on Premorbid IQ (NART/WAIS Vocabulary) for Separate Disciplines

	Total Sample	Nursing	Psychology	Physiotherapy	Occupational Therapy	Social Work	Speech Pathology	Dietetics
Referrals	N = 121	n = 105	n = 92	n = 44	n =35	n = 28	n = 7	n = 4
Low IQ (< 100)	67 (55%)	85%	81%	24%	27%	25%	2%	6%
High IQ (≥ 100)	54 (45%)	89%	70%	52%	32%	20%	11%	0%
χ^2 (*df*)		.379 (1)	1.72 (1)	10.11	.31	.42		
p		.54	.19	**.001**	.58	.52		
Appointments/HV		n = 60	n = 79	n = 41	n = 22 [a]	n = 15 [a]	n = 5	n = 4
Low IQ (< 100)		63%	87%	94%	78%	47%	0%	100%
High IQ (≥ 100)		50%	84%	93%	47%	64%	83%	
χ^2 (*df*)		1.84	.15					
p		.18	.70	1.00	.08	.46		
Attendances/HV		n = 52	n = 62	n = 34 [a]	n = 25 [a]	n = 13 [a]	n = 5	n = 3
Low IQ (< 100)		86%	37%	87%	86%	75%		75%
High IQ (≥ 100)		88%	25%	81%	75%	100%	100%	
χ^2 (*df*)		.02	2.59					
p		.88	.11	1.00	.60	.47		

Note. [a] Fishers Exact test was used, in accordance with McPherson (1990), because n < 40 or at least one cell has an expected count < 3.

In summary, the findings for demographic and initial contact variables were:

- Increased service utilisation, as measured by the number of disciplines participants were referred to, was not significantly associated with gender, years of education or estimated premorbid IQ.
- There was a trend towards an association between increased service utilisation and increased age (p = .049).
- HVs were conducted in four disciplines, Nursing, Social Work, Occupational Therapy and Psychology. In Nursing, a significant proportion (39%) of the sample received a home visit, while in the other disciplines HVs took place in a much smaller percentage of the sample.
- Much larger percentages of the sample were referred to Nursing (87%) and Psychology (78%) than to the other clinical disciplines (e.g. 33% were referred to Physiotherapy and smaller percentages to the other disciplines).
- Participants referred from the TNTR were more likely to be referred to the discipline of Nursing (p <.001), than participants referred from other sources.
- Participants referred by hospital and community medical services were more likely to be referred to Physiotherapy (p <.001) and Occupational Therapy (p <.001) than participants referred by TNTR.
- Those over 30 years of age (p = .009) and those with higher estimated premorbid IQ (p = .001) were more likely to be referred to Physiotherapy, than participants who were younger and/or had lower IQ
- There was a trend (p = .037) for Physiotherapy to receive referrals for those with higher education (> 11 years), but appointments were more likely (p = .005) to be offered to those with lower education (≤ 11 years).

- There was a strong tendency for Nursing to offer more appointment to women compared to men (p = .020).
- There was a trend (p =.043) towards an association between older age (> 30 years) and referral to Occupational Therapy.

7.4 Discussion

This study examined the demographic characteristics of the two groups (CRU-Other and CRU-TNTR) from study 1 referred for rehabilitation in the public sector and aimed to investigate how those characteristics impacted on their referral to CRU's seven disciplines, the probability of being offered appointments and, the probability of attending them. The relationship between demographic variables and the number of disciplines participants were referred to was also examined.

As reviewed in chapter 3 of this thesis, a large amount of research has documented poorer outcomes for older TBI patients, and those with lower levels of education. Although there are few TBI outcome studies which include estimated premorbid IQ as a variable, the correlation of IQ and lower education levels suggest that lower premorbid IQ may also be a risk factor for poor outcomes. It was therefore hypothesised that older people, and those with lower levels of education and IQ, would be greater consumers of rehabilitation services. This could be reflected in greater access to the service through referral to a greater number of disciplines (service utilisation) and/or higher intensity of use, reflected in greater number of hours of therapy. Intensity of service as measured by hours of therapy will be examined in study 5. The present study looked at service utilisation, as measured by the number of disciplines participants were referred to, and found no relationship between education, gender or IQ and service utilisation. However there was a trend towards an association between older age and increased service utilisation (p =.049).

It is important to note that the analysis in the current study split the sample at 30 years of age, and therefore *older age* refers to a group which has participants who could be characterised as middle aged or even as young, whereas poorer outcomes have largely been linked to those over 60 years (Goleburn & Golden, 2001; Rothweiler, et al., 1998; Whiteneck, et al., 2004a), or in the case of employment outcomes in those over the age of 40 (Keyser-Marcus, et al., 2002). For these reasons, it was decided to explore the effect of age further, to see if splitting the sample into an older group (for example over 50 or over 60 years) would result in a stronger association. Examination of service utilisation in the sample split into four age categories (16—30, 31—40, 41—59 and > 59) indicated that, whereas only 38% of the 16 to 30 year old sample were referred to three or more disciplines, for the other three age bands the percentage referred to three or more disciplines was 53% in each case. Splitting the sample at 40 years, 50 years or 60 years did not therefore show an association between increased age and referral to more disciplines (see Appendix Q) for the results of this analysis), and it was apparent that the effect of age on service utilisation in this study was an association between younger age and referral to fewer disciplines, rather than an association of referral to more disciplines in older adults. It may be that those in the 16 to 30 year old age bracket had incurred milder injuries with fewer other system injuries from the same accident, resulting in referral to only one or two disciplines, for example to Nursing and/or Psychology. The question of whether those with milder injures were referred to fewer disciplines will be examined further in the next study.

The majority of participants (87%) in the sample were referred to the discipline of Nursing, and more than three quarters were referred to the discipline of Psychology, whereas much smaller proportions were referred to Physiotherapy (33%), Occupational Therapy (29%) and Social Work (26%). Speech Pathology received very few referrals

(7%) and Dietetics (2%) even fewer. This pattern of utilisation is in contrast with studies overseas (High Jr, et al., 1995; Phillips, et al., 2004) and in Australia (Hodgkinson, et al., 2000) which found that the more traditional physical rehabilitation disciplines such as physiotherapy, speech pathology and occupational therapy were accessed more frequently than psychology or counselling services. This discrepancy may reflect the characteristics of the sample which included a high proportion (52% of the whole sample) of mild injuries, whereas the studies cited above had less than 20% of injuries categorised as mild. Individuals with mild injuries may have been referred to Psychology and Nursing for education, reassurance and assistance with PCS, and not been referred to Occupational Therapy, Physiotherapy or Speech Pathology.

Another explanation for the high proportion of participants referred to both Psychology and Nursing is the possibility of a referral bias from TNTR, which was responsible for a large proportion (69%) of referrals to CRU. The majority of staff at TNTR were provisionally registered psychologists, who might be expected to refer study participants for psychological services more frequently than the average health professional. Referrals from TNTR were also frequently directed, in the first instance, to Nursing because the TNTR research assistants were aware that one of the rehabilitation nurses was active in coordinating follow-up for TBI patients. This may have been one cause of the high percentage of participants referred to Nursing. To examine this in more detail, the proportion of referrals to each of the five main disciplines was compared for the two referral groups (CRU-TNTR and CRU-Other). Results, which are displayed in table 7.4, indicated that the sample referred from TNTR was more likely to be referred to Nursing (p <.001) and the sample referred from other sources was more likely to be referred to Physiotherapy (p <.001) and Occupational Therapy (p <.001). However for Psychology and Social Work no significant differences were found, indicating that although TNTR participants were more likely to be referred to Nursing, there was no referral bias in favour of Psychology for TNTR referrals.

Clearly variations in health care systems in different countries and different localities will affect service utilisation following TBI. The clinical services available at CRU during the course of this study can therefore be expected to be a major factor in the service utilisation for participants of the current study. However, despite the fact that Physiotherapy and Occupational Therapy services were the largest clinical disciplines at CRU—each with about the equivalent of six full-time staff—these disciplines received fewer referrals than the discipline of Psychology which had only a maximum of two full-time equivalent staff during the course of this research. In an Australian study of service utilisation by Hodgkinson et al. (2000), although few participants accessed counselling and psychological services, neuropsychology was the allied health service most frequently accessed in the first two years post-injury. In the present study those referred for neuropsychological assessments are not distinguished from those who were referred for clinical psychology, because of the amalgamation of these services in 2005, so it is more difficult to distinguish between the two services. However the number of participants who received a neuropsychological assessment (32%) may at least in part account for the large proportion of cases referred to Psychology in the present study.

Additionally, the comparison of the proportion of referrals these two disciplines received for the two referral groups (CRU-TNTR and CRU-Other) displayed in table 7.4 indicates that only 24% of those were referred by TNTR were subsequently referred to Physiotherapy and only 15% to Occupational Therapy, compared with more than half of those referred from the other sources. This may reflect the nature of the sample, which as outlined in study 1, included a large number of mild injuries and non-hospitalised cases. Those with milder injuries, who had not been hospitalised following their injury, may not have had the kinds of physical problems which would need intervention by rehabilitation disciplines such as Physiotherapy and Occupational Therapy. However it could also reflect the TNTR research assistants' lack of awareness of the nature of these services and who could potentially benefit from them.

Speech Pathology services are primarily indicated for specific neurological disorders which involve problems with swallowing and feeding, communication, and respiratory dysfunction (Tasmanian Department of Health and Human Services, 2003). Those TBI patients requiring this type of service are likely to be only those with severe injuries, which constituted only a small proportion of the current sample. However, it is likely that there was an area of unmet need for speech pathology services in the current sample, due to the very limited service available at CRU, and the gap in services experienced in 2005. Dietetics was also a very small service at CRU with only one staff member available one-day a week during the course of this study. The reasons for this may be a perceived lack of need for information about diet and nutrition in the patients receiving rehabilitation services at CRU. On the other hand, it may be due to non-availability of this service. This was not explored in the present study, as information on nutrition and diet, while valuable for many health conditions and in the prevention of chronic diseases, is not specifically indicated following TBI.

Home visits (HVs) were conducted in four disciplines: Nursing, Social Work, Occupational Therapy and Psychology. In Nursing a significant proportion (44%) of the sample received a HV, and most HVs were for the purpose of conducting an initial assessment, while in the other disciplines HVs were usually used for other purposes, such as assisting with service liaison. As outlined in chapter 4, TBI guidelines (for example New Zealand Guidelines Group, 2006) recommend a proactive approach to intervention for TBI patients, which identifies potential barriers to therapy in advance rather than relying on the consequences of behaviour, as is commonly advocated in behavioural interventions. In patients with memory and executive functioning deficits, which may result in their missing appointments because of disorganisation or simply forgetting about them, the use of HVs can be viewed as a proactive approach. This type of approach may also be useful for those with high levels of anxiety which may be a barrier to their attending appointments, particularly initial appointments with a new service. The question then arises: were HV associated with a greater level of engagement with CRU's clinical services? This question will be addressed in study 5 of this thesis which looks at the amount and nature of therapy that participants received at CRU.

The results of the present study indicated that older age was associated with referral to Physiotherapy, and there was also a trend towards increased likelihood of referral to Occupational Therapy for older (>30 years) participants. This may be because older TBI patients are more likely to have other-system injuries from the incident or accident that resulted in the TBI, requiring input from a number of different disciplines. A review of the literature (Goleburn & Golden, 2001) on TBI outcome in older adults found that extra-cranial medical complications were more common in older adults. For example Roy and Pentland (1986) in a study of 190 consecutive patients, 65 years and older, identified 146 with mild injures, as measured by an admission Glasgow Coma Scale (GCS) score of 12 to 15. Two thirds of these patients had suffered concomitant medical injuries, most frequently orthopaedic in nature. Consideration of co-morbidities was outside of the scope of the present research. However falls, which are a common cause of TBI in older adults (Kraus & McArthur, 1999), are more likely to result in orthopaedic injuries in this population, than in young people (Kannus, et al., 1997). As those with fractures might be expected to be treated by Physiotherapy at CRU, an examination of referral patterns by cause of injury in the next study may shed further light on this question.

The present study looked at how participants' estimated premorbid IQ scores were related to the pattern of their referral to the clinical disciplines at CRU, and some differences were found in Physiotherapy: Those with higher IQ were more likely to be referred to Physiotherapy than those in the lower IQ group. As reviewed in chapter 3, there is little research which has directly examined pre-morbid intellectual functioning on outcome. The few studies that have been carried out indicate that individuals with lower IQ are likely to be at risk for poorer outcomes, and therefore more in need of assistance from rehabilitation services, than those with higher intelligence. This does not explain why participants in the current study with higher IQ would be more likely to be referred for Physiotherapy. However, as outlined above, referrals to Physiotherapy tended to be older, possibly because of a need for assistance with physical problems and orthopaedic injuries. In the current study premorbid IQ was estimated using the National Adult Reading Test (NART; Nelson, 1982) for the majority of participants. Early research (Crawford et al., 1989) has suggested that age does correlate with NART errors, although the authors concluded this was due to the concurrent effects of education and social class. However, an unpublished study (Dean, 2009) looking at the clinical utility of the NART as an estimate of premorbid IQ in 194 TBI patients from the TNTR sample, found that younger participants (16 to 24 years of age) made significantly more NART errors than older groups (41 to 60 years of age and 61 to 80 years of age). The results of the current analysis may reflect the higher number of referrals to Physiotherapy for older participants, who scored fewer errors on the NART.

In order to explore this question further, the difference in the mean IQ of the sample split into age groups (16—30, 31—40, 41—59 and > 59 years) was investigated with a one-way ANOVA (see Appendix R). The results did indicate that there was a significant difference between the youngest age group which had a mean IQ score of 92.39 and the 41—59 years of age group which had a mean score of 102.14 (p = .003). There was also a difference approaching significance between the youngest age group and the over 59 years of age sample, which had a mean score of and 102.77 (p = .028).

As outlined in chapter 4, Social Work services at CRU help patients to access resources, and the discipline of Nursing frequently took on a case management role for TBI patients, largely due to the personal interest of one of the rehabilitation nurses. It was therefore hypothesised that individuals who have fewer resources, in terms of lower education and lower intellectual ability, would access these services more frequently than higher functioning individuals, as has been found in previous research (High Jr, et al., 1995). Results of the present study failed to find an association between lower levels of education and referral to any of CRU's disciplines. This may reflect the fact CRU's intake process did not include a system to screen for factors such as lower education, unemployment or lower IQ, which previous research has indicated are associated with poorer outcomes (Hoofien, et al., 2002; Sherer, et al., 2003; Vanderploeg, et al., 2003). It may also be a result of the fact that the majority (87%) of the sample were referred to Nursing.

The hypothesis, based on previous research in USA (High Jr, et al., 1995), that women and those with higher levels of education would be more likely to be referred to Psychology for counselling services was also not supported. This result may be due to differences in health care systems and also to the nature of the sample: The USA study was conducted with a largely self-selected group of TBI patients, active in regional TBI centre community groups, who had sustained a TBI an average of six years prior to the study. They may therefore have been more likely to be active in seeking assistance for ongoing PCS, compared with the participants of the present study, the majority (93%) of which were referred within the first year post-injury to publicly funded rehabilitation.

Although there was a trend (p = .037) for Physiotherapy to receive referrals for those with higher education (> 11 years), surprisingly appointments in Physiotherapy were more likely to be given to those with fewer years of education. This may indicate follow-up by Physiotherapy of individuals with a lower education, who might be expected to have a lower chance of a good outcome. Alternatively however, it may reflect follow-up of older participants, because the group referred to Physiotherapy was significantly older than the rest of the sample, and there was a trend (p =.051) towards Physiotherapy offering more appointments to older participants. Older participants might be expected to have fewer years of education than younger ones, because of the increasing levels of education in the general population over the last four or five decades. Further analysis of the sample found no significant difference in the mean years of education for older participants compared with younger ones, but there was a significant difference, χ^2 (1) = 7.69, p =.006, in the percentage of participants with ≤ 10 years education in those 60 years of age and above (68%) compared with the 16 to 30 years-of-age group (47%). Further details of this analysis can be found in Appendix S. Therefore it can be concluded that the finding that Physiotherapy gave more appointment to those with fewer years of education, is probably due to the association of fewer years of education with older participants and a reflection of follow-up of older participants by Physiotherapy.

The gender ratio for TBI in adults found in epidemiological studies is about two males injured for every female (Hillier, et al., 1997) and this was reflected in the gender ratio of participants in this study (68% male). There were no significant differences in the proportions of males and females referred to separate disciplines. However there was a tendency for the discipline of Nursing to offer more appointments to women than men. The rehabilitation nurses at CRU provided initial support and education to TBI patients, and were often their first point of contact with the service as well as being the liaison between the brain injury clinic and the rehabilitation services provided by CRU. As outlined in chapter 3, previous research has indicated that women have worse TBI outcomes (Farace & Alves, 2000; Whiteneck, et al., 2004a) than men, and that women are more likely to adhere to medical treatment than men (DiMatteo, 2004). The tendency to give more CRU appointments by Nursing to women, compared to men, may therefore reflect either follow-up of those who the rehabilitation nurses saw as more at risk of poor outcomes, or a greater willingness on the part of females to attend appointments.

7.4.1 Limitations.

As described in study 1, the large proportion of cases referred by TNTR research assistants were different in many respects from the sample referred by hospital and community services and this may limit the ability of the current study's results to be generalised to other services. However, it is important to note that these individuals were referred because they presented with high levels of psychological distress, pain, fatigue and PCS. As rehabilitation interventions have been recommended for TBI patients of all severities, except the very mildest of injuries, information about their engagement or lack-of-engagement, with CRU's clinical services can therefore provide valuable information that may not be available from other studies.

Another limitation of the present study is the large proportion of missing data for pre-morbid intellectual functioning. Data were missing on this variable for 31% of participants for reasons outlined in chapter 5. However because information about premorbid IQ is not usually available in TBI outcome studies, the research reported in this study provides valuable information about this variable in a TBI sample referred to post-acute rehabilitation.

7.4.2 Summary and research directions.

This study has provided information about the disciplines that the sample of TBI patients were referred to, as well as some indications of some demographic variables that may have influenced the nature of clinical services offered to them. A larger proportion of the sample were referred to the disciplines of Nursing and Psychology than were referred to the more traditional rehabilitation disciplines of Physiotherapy and Occupational Therapy, even though the latter disciplines had much higher staffing levels. This may be due to the nature of the sample which included a high proportion of non-hospitalised cases and mild injuries. It may also be that some TBI patients who could have benefited from intervention by Occupational Therapy and Physiotherapy were not referred due to a referral bias in referrals received from TNTR. Speech Pathology and Dietetics received few referrals. This may have been due to their very small staff, but it is also likely that there was an area of unmet need for speech pathology services in the current sample, due to the very limited service available at CRU, and the gap in services experienced in 2005.

Although the variables considered, particularly increasing age and fewer years of education, have been shown to influence outcome following TBI, this study did not find an association between any of them and referral to more clinical disciplines. However there was a trend towards those in the youngest age bracket (16 to 30 years) being referred to fewer disciplines. The discipline of Physiotherapy was more likely to receive referrals for older participants (>30 years) and there was a trend towards

Occupational Therapy also receiving more referrals for those in the older age bracket. This may be due, in part, to other-system injuries, such as orthopaedic injuries, incurred at the same time as the TBI, consideration of which was outside of the scope of the present research. Nevertheless, information on cause of injury will partially address this question. Those with higher estimated premorbid IQ were more likely to be referred to Physiotherapy. This may be due to an association of higher premorbid IQ scores with older age, as post hoc analyses did find a significant association between higher premorbid IQ and increasing age. Lower levels of education were not associated with referral in any discipline, but the discipline of Physiotherapy was more likely to offer appointments to those with lower levels of education. This may reflect follow-up of older patients, who might be expected to have fewer years of education, because of the rising level of education over the last four or five decades. There was a trend towards Nursing giving more appointments or HVs to women than men, possibly reflecting follow-up of those at risk of poorer outcomes, or a greater willingness on the part of females to attend appointments.

In developing a model of pathways of rehabilitation, which is one of the overall aims of the current research, results of the current study suggest it will be important to note the following factors:

- Follow-up of TBI patients with mild injuries may require more input from Psychology than from more traditional rehabilitation disciplines such as Physiotherapy and Occupational Therapy
- Meeting the rehabilitation needs of mTBI patients may require additional resources to provide educational interventions. In the present study this was provided by Nursing, but other disciplines such as Occupational

Therapy or Social Work may also be able to offer this type of intervention

- Those in the younger age bracket (16 to 30 years) may have different needs compared with older TBI patients.
- Women may need more follow-up, and/or be more willing to engage in therapy than men

Some questions raised by the present study are:

- Were individuals with milder injuries referred to fewer CRU clinical disciplines, and, if so, were they mainly referred to Nursing and Psychology (for education and reassurance)?
- Were those injured in a fall more likely to be referred to Physiotherapy and Occupational Therapy, than those injured by other causes?
- Did contact by home visit, particularly initial contact, result in greater engagement with the service compared to initial contact at CRU?

The first two questions will be examined in study 3 the results of which are reported in chapter 8. The third questions will be addressed in study 5 which will look in more detail at this group of TBI patients' engagement with CRU services by investigating the amount and nature of therapy that they were given.

Study 3, described in the next chapter, will consider how a range of injury-related variables of the current TBI sample were related to their initial progress in therapy at CRU.

CHAPTER 8 - Study 3: The Relationship Between Injury-related Variables and Initial Contact with CRU's Clinical Services

Study 2 described how some demographic characteristics, of TNTR participants referred for public post-acute rehabilitation in the community, were related to their initial contact with the Community Rehabilitation Unit's (CRU's) clinical services. The current chapter will consider how the injury-related variables of previous TBI, cause of injury, injury-severity and hospitalisation were related to this initial contact. Chapter 3 provides a review of the research that has looked at these injury-related variables, and their relationship with outcome after TBI. The following is a summary of that research.

In moderate to severe injuries, the severity of the injury is the most important of the injury-related predictors of outcome, with more severe injuries having worse outcomes, but measures of injury-severity such as PTA have not been found to be a predictor of poor outcome in mild injuries. Individuals whose injury is incurred in a violence-related incident have been shown to experience more post-concussion symptoms (PCS) and greater disruption of cognitive functioning that those injured by other causes. Few prognostic studies of TBI include hospitalisation as a variable, but those which do suggest that more PCS and poorer functional outcomes are experienced by individuals who are admitted to hospital, even if their injury is mild. A history of previous TBI has been shown to be related to greater cognitive impairment, more PCS and an increased risk of incurring another TBI.

A study of service utilisation post-TBI, cited in chapter 5 (Phillips, et al., 2004), indicated that in the first three months following their injury, individuals with mild and moderate injuries are as likely to use a range of medical and rehabilitation services as those with severe injuries. In the longer term, utilisation of most services increases as a function of severity of injury (Brooks, Lindstrom, McCray, & Whiteneck, 1995; High Jr, et al., 1995; Hodgkinson, et al., 2000; Phillips, et al., 2004). However use of psychological services has been found to be inversely related to injury-severity: Those with milder injuries access these services more frequently (High Jr, et al., 1995).

8.1 Aims and Hypotheses

The present study aimed to examine the injury-related characteristics of the TNTR sample referred to CRU, and look at how they impacted on the probability of their being offered an appointment in one or more of its seven clinical disciplines and, for the cohort who were offered appointments, the probability of attending them. The relationship between these injury-related variables and service utilisation, as measured by the number of disciplines participants were referred to, was also examined.

8.1.1 Questions raised by previous studies.

The following two questions raised in study 2 will be addressed in the present study:

- Were individuals with milder injuries referred to fewer CRU clinical disciplines, and if so were they mainly referred to Nursing and Psychology (for education and reassurance)?
- Were those injured in a fall more likely to be referred to Physiotherapy and Occupational Therapy, than those injured by other causes?

Based on the research reviewed in chapters 3 and 5 of this thesis, and summarised above, it was hypothesised that:

- Participants with more severe injuries would be referred to more CRU disciplines.

- Participants whose injury was caused by an assault would be referred to more CRU disciplines.
- Participants who were hospitalised following their injury would be referred to more CRU disciplines.
- Participants who had experienced a previous TBI would be referred to more CRU disciplines
- Because hospitalisation following TBI may be for physical injuries, those hospitalised would be more likely to be referred to the disciplines of Physiotherapy and Occupational Therapy, which typically provide rehabilitation for physical injuries such as fractures.
- Participants with mild injuries would be more likely to access psychological services, than participants with moderate or severe injuries.

8.2 Method

8.2.1 Participants.

All participants for this study were individuals who had consented to be part of the Tasmanian Neurotrauma Register (TNTR) research project following a TBI. This project has been described in more detail in chapter 6 of this thesis. Eligibility criteria for the present study were individuals in the TNTR outcome study who had been referred to the Community Rehabilitation Unit (CRU) for rehabilitation and whose treatment was provided by CRU clinicians. A total of 175 individuals were included in the present study. The demographic characteristics of the sample are outlined in study 2 in Chapter 7. The injury-related characteristics of the sample are outlined in table 8.1 below.

The ACMR definition (Kay, et al., 1993) was used to characterise a mTBI (see chapter 2), as one where post traumatic amnesia (PTA) does not exceed twenty four hours. The proportion of moderate to severe injuries was greater in this sub-sample, compared to the whole TNTR sample described in study 1 (48% compared with 26%). The percentage of participants injured in a fall was comparable, but there was a larger percentage of assault-related TBI in the current sample compared with the whole TNTR sample in study 1 (39% compared with 27%) and fewer transport-related injuries. The percentage of those with a previous history of TBI was much greater (20% compared with 7%), but the proportions of cases that had been hospitalised following their injury was very similar (47% compared with 48%).

Table 8.1
Injury-related Characteristics of the Whole Sample

Severity (*N* = 175)		Cause of TBI (*N* = 175)	
Mean PTA	5.54 (11.05)	Assaults	69 (39%)
Range	0-66	Transport-related	51 (29%)
Median	1.00	Falls	42 (24%)
Mild (≤ 24 hours PTA)	91 (52%)	Sporting	3 (2%)
Moderate (> 1 day-7 days PTA)	54 (31%)	Other	10 (6%)
Severe (>7 days PTA)	30 (17%)		
Previous TBI (*N* = 175)		**Hospitalisation (*N* = 175)**	
Previous TBI	35 (20%)	Hospitalised	82 (47%)
No previous TBI	140 (80%)	Not Hospitalised	93 (53%)

8.2.2 Clinical disciplines.

Seven clinical disciplines were operating at CRU during the period of this study: Nursing, Physiotherapy, Occupational Therapy, Social Work, Psychology, Speech Pathology and Dietetics. Details of the operation of these clinical disciplines during the period of this study have been outlined in chapters 5 and 6.

8.2.3 Design.

This study used a cross-sectional design, with adults who had sustained a TBI and had been referred for rehabilitation to CRU. Data on the variables of injury-severity (PTA), cause of injury, previous TBI and hospitalisation were collected as soon as possible following participants' injury and emergence from post-traumatic amnesia (PTA), to investigate their role in relation to referral for rehabilitation and initial contact with CRU's clinical services. Information about participants' referral to CRU and to its clinical disciplines was obtained from CRU clinical files.

8.2.4 Procedure.

The procedure followed in this study, including the method of obtaining informed consent, was identical to that used in study 2 and described in chapter 7 of this thesis.

In addition, the following data for each participant was obtained from assessments performed at the TNTR and/or from the hospital medical records:

- Cause of injury
- History of previous TBI.
- Length of post traumatic amnesia (PTA)
- Length of any period of hospitalisation immediately following the injury.

TNTR's participants were recruited through the ED at the RHH. Individuals who were admitted to the hospital and spent at least one day as an inpatient were categorised as having been hospitalised following their injury. Participants who spent a number of hours in ED, but were not subsequently admitted to the hospital, were categorised as not being hospitalised.

Participants were divided in to two or three groups for each variable as follows:

Cause of injury	Assaults / Transport-related / Falls
Previous TBI	No previous TBI / Previous TBI
Injury-severity	Mild (≤ 24 hrs PTA) / Mod/Severe (> 1 day PTA)
Hospitalisation	Not hospitalised / Hospitalised

The three main causes of injury, assaults, transport-related and falls were considered in the analyses for this study—the small proportion of cases (8% of the sample) who were injured as a result of other or unknown causes were not included.

8.2.5 Analyses.

Chi-square analyses were used to explore the impact of the variables of previous TBI injury-severity, hospitalisation and cause of injury on service utilisation, by comparing the percentage of participants referred to ≤ 2 disciplines with the percentage referred to > 2 disciplines for each variable. Chi-square analyses were also used to explore the impact of these variables on referral to CRU's five largest disciplines, Nursing, Psychology, Physiotherapy, Occupational Therapy and Social Work, on participants being offered an appointment or a home visit (HV) in each of those disciplines and, for those who were offered one to the likelihood of their attending it. These tests were not performed for Speech Pathology and Dietetics, because of the small samples referred to these disciplines. For cause of injury, when the global chi-square test indicated that there was a difference between the three groups at the level of p <.05, post-hoc tests were performed between the three pairs (Assaults/Transport; Assaults/Falls; Transport/Falls) to determine which pairs differed significantly.

8.3 Results

The results of this study are presented in two sections. The first section looks at service utilisation, as measured by the number of disciplines participants were referred to, and considers how the variables of cause of injury, hospitalisation, previous TBI and injury-severity (PTA) are related to it. The second section looks at how these variables relate to participants' referral to each of the CRU clinical disciplines, to the probability of their being offered an appointment or HV in a discipline and to the probability of their attending an appointment/receiving a home visit if offered one.

8.3.1 Referrals to CRU clinical disciplines.

Details of the total numbers of CRU disciplines study participants were referred to are presented in table 7.5 in chapter 7.

Table 8.2 displays the results of chi-square analyses of study variables on service utilisation, as measured by the number of disciplines participants were referred to: There was a significant difference for injury-severity, with those having a longer PTA being more likely to be referred to more than two clinical disciplines. There was also a tendency for those who had experienced a previous TBI to be referred to more disciplines, although this failed to reach statistical significance (p = .041).

Table 8.2

Effect of PTA, Previous TBI, Hospitalisation and Cause of Injury on Service Utilisation

	Referral to > 2 disciplines	*n*	χ2	*df*	*p*
Severity (*n* = 175)			7.70	1	**.006**
≤ 24 hr PTA	37%	34			
>24 hr PTA	58%	49			
Previous TBI (*n* = 175)					
No previous TBI	44%	61	4.18	1	.041
Previous TBI	63%	22			
Hospitalisation (*n* = 173)					
Not hospitalised	43%	35	1.39	1	.24
Hospitalised	52%	48			
Cause of injury (*n* = 162)					
Assaults	45%	23	0.46	2	.80
Transport	44%	30			
Falls	50%	21			

8.3.2 Initial contact with clinical disciplines.

Table 7.5 in chapter 7 of this thesis shows the number and percentage of the sample referred to each discipline, the number and percentage of referrals offered an initial appointment, or HV, by each discipline and the number and percentage of those offered an appointment or HV who attended it. As outlined in chapter 7, HVs were conducted in the disciplines of Nursing, Social Work, Occupational Therapy and Psychology.

For five of the seven disciplines, chi-square analyses were used to compare the groups referred to each discipline; those offered an appointment or HV, and those who attended appointments on the injury-related variables of injury-severity, previous TBI, hospitalisation and cause of injury. Due to the small numbers in the samples referred to Speech Pathology and Dietetics analyses were not performed for these disciplines.

8.3.2.1 Cause of injury.

Table 8.3 gives chi-square analyses for cause of injury for each of the disciplines. No statistically significant differences were found overall, but the results for Psychology (*p* = .012) and Occupational Therapy (*p* = .045) approached significance. Post hoc analyses comparing the three causes pair-wise (Assaults/Transport; Assaults/Falls; Transport/Falls) indicated that there was a significant difference in the percentage (87%) of assault-related cases referred to Psychology, compared with the percentage (65%) of transport-related cases, χ^2 (1) = 8.33, *p*=.004. There was also a tendency for those injured in a fall to be referred to Occupational Therapy, more frequently than those injured in assault-related TBI, but this association was only approaching significance (χ^2 = 6.21 (1), *p* = .013). The details of these analyses can be found in Appendix T.

8.3.2.2 Previous TBI.

Chi-square analyses for previous TBI are presented in table 8.4: there were no statistically significant results. However, there was a tendency for more of those with a history of previous TBI to be referred to Psychology (*p* = .035) than those who had not sustained a previous TBI. In addition, although there was no significant difference in referrals to Nursing for previous TBI, there was a tendency for Nursing to offer more appointments to those who had sustained a previous TBI than to participants who had not sustained one (*p* = .049).

8.3.2.3 Injury-severity.

Table 8.5 presents results of chi-square analyses for injury-severity. The results indicated that those with more severe injuries were more likely to be referred to Physiotherapy (*p* = .003) and Occupational Therapy (*p* = <.001) than those with mild injuries. No significant differences were found for injury-severity in appointments offered in any of the disciplines. Those with moderate to severe injuries were more likely to attend an appointment/home visit in Nursing than those with mild injures (p = .004).

8.3.2.4 Hospitalisation.

Table 8.6 presents chi-square analyses for hospitalisation for the samples referred. The results indicated that those who were hospitalised following their injury were more likely to be referred to Physiotherapy (p = .009) than those who had not been admitted to hospital.   There was also a tendency for more of the hospitalised sample to be referred to Occupational Therapy than those who had not been hospitalised following their injury (p = .013).

The following is a summary of some of the injury characteristics of the samples referred to each discipline:

8.3.2.5 Nursing.

There were no significant differences in the sample referred for Nursing on the injury-related variables examined in this study. There was a tendency for Nursing to offer more appointments or HVs to those who had experienced a previous TBI, compared with those without a history of head injury but this failed to reach significance (p = .049).   All of the participants with moderate to severe injuries who were offered an appointment or HV by Nursing attended it, compared with 80% attendance by the mildly injured sample. This difference was statistically significant (p = .004).

8.3.2.6 Psychology.

There was a tendency for Participants who had suffered a previous TBI to be referred to Psychology more frequently than those who had no previous head injury (p = .035). Those with assault related injuries were more likely to be referred to Psychology, than those with transport-related injuries (p = .004).

8.3.2.7 Physiotherapy.

Physiotherapy was more likely to receive referrals for those who had moderate to severe injuries (p = .003) and those who had been admitted to hospital (p = .009), than those with mild injuries or those who had not had a period of hospitalisation following their injury.

8.3.2.8 Occupational therapy.

Participants who had moderate to severe injuries were more likely to be referred to Occupational Therapy, than those with mild injuries (p = <.001). There was also a very strong tendency for Occupational Therapy to receive more referrals from those who had been admitted to hospital following their injury than those who had not been hospitalised (p = .013). A larger proportion of those injured in a fall were referred to Occupational Therapy, compared with those injured in assault-related TBI, this association verging on statistical significance , χ^2 (1) = 6.21, p =.013).

8.3.2.9 Social work.

No statistically significant differences were found for any of the analyses in this study for the sample referred to Social Work.

Table 8.3
Cause of Injury Information for Separate Disciplines

	Total Sample	Nursing	Psychology	Physiotherapy	Occupational Therapy	Social Work	Speech Pathology	Dietetics
Referrals	N = 162	n = 141	n = 127	n = 53	n = 44	n = 41	n = 12	n = 4
Assaults	69	90%	87% *	35%	19%	28%	4%	1%
Transport	51	88%	65% *	37%	28%	22%	8%	2%
Falls	42	81%	81%	41%	41%	26%	12%	5%
χ^2 (df)		1.93 (2)	8.79 (2)	3.67 (3)	6.18 (2)	.58 (2)		
p		.38	.012	.16	.045	.75		
App./HV offered		n = 79	n = 102	n = 46	n = 31	n = 24	n = 8	n = 4
Assaults		55%	75%	94%	69%	63%	67%	100%
Transport		47%	795	79%	57%	36%	50%	100%
Falls		71%	91%	88%	82%	73%	80%	100%
χ^2 (df)		4.56 (2)	3.66 (2)	1.85 (2)	2.36 (2)	.33 (2)		
p		.10	.16	.40	.31	.14		
Appt./HV attended		n = 70 [a]	n = 81	n = 38	n = 24 [a]	n = 17 [a]	n = 6	n = 3
Assaults		88%	73%	69%	89%	58%	50%	100%
Transport		91%	78%	87%	63%	50%	100%	0
Falls		88%	87%	93%	79%	100%	75%	100%
χ^2 (df)			1.83 (2)	3.51 (2)				
p			.40	.17				

Note. [a] chi-square value was not calculated because at least one cell has an expected count < 3
[*] significantly-different groups (assault-related versus transport-related referrals to Psychology: χ^2 (1) = 8.33, p=.004)

Table 8.4
Information on Previous TBI for Separate Disciplines

Percent previous TBI	Total Sample	Nursing	Psychology	Physiotherapy	Occupational Therapy	Social Work	Speech Pathology	Dietetics
Referrals	*N* = 175	*n* = 152	*n* = 137	*n* = 58	*n* =50	*n* = 45	*n* = 12	*n* = 4
No previous TBI	140 (80%)	85%	75%	31%	28%	24%	6%	1%
Previous TBI	35 (20%)	94%	91%	40%	31%	34%	9%	6%
χ^2 (*df*)		2.12	4.45 (1)	.923 (1)	.18 (1)	1.68 (1)		
p		.15	.035	.34	.68	.19		
Appointments		*n* = 83	*n* = 109	*n* = 51 [a]	*n* = 33	*n* = 26	*n* = 8	*n* = 4
No previous TBI		50%	77%	39%	675	52%	56%	100%
Previous TBI		70%	88%	12%	64%	75%	100%	100%
χ^2 (*df*)		3.87 (1)	1.62 (1)		0.04 (1)	1.99 (1)		
p		.049	.20	.18	.85	.16		
Attendances		*n* = 73 [a]	*n* = 85	*n* = 42	*n* = 25 [a]	*n* = 18 [a]	*n* = 6	*n* = 3
No previous TBI		87%	75%	81%	73%	59%	80%	100%
Previous TBI		91%	86%	86%	86%	89%	67%	50%
χ^2 (*df*)			1.31 (1)					
p		.72	.25	1.00	.65	.19		

Note. [a] Fishers Exact test was used, in accordance with McPherson (1990), because n < 40, or at least one cell has an expected count < 3

Table 8.5

Injury-severity (PTA) Information for Separate Disciplines

Percent referred	Total Sample	Nursing	Psychology	Physiotherapy	Occupational Therapy	Social Work	Speech Pathology	Dietetics
Referrals	N = 175	n = 152	n = 137	n = 58	n =50	n = 45	n = 12	n = 4
Mild (≤1 day PTA)	91 (52%)	91%	79%	23%	17%	24%	7%	1%
Mod/Severe (>1 day PTA)	84 (48%)	82%	77%	44%	42%	27%	7%	4%
χ^2 (*df*)		3.15 (1)	.078 (1)	8.67 (1)	13.57 (1)	.24 (1)	.021 (1)	
p		.076	.78	**.003**	**<.001**	.63	.89	
Appointments		n = 83	n = 109	n = 51	n = 34	n = 26	n = 8	n = 4
Mild (≤1 day PTA)		58%	76%	95%	73%	64%	64%	25%
Mod/Severe (>1 day PTA)		51%	83%	84%	63%	52%	52%	53%
χ^2 (*df*)		.768 (1)	.94 (1)		.514 (1)	.61 (1)	.00(1)	
p		.38	.33	.40	.81	.44	1	
Attendances		n = 73	n = 85	n = 42	n = 25 [a]	n = 18 [a]	n = 6	n = 3
Mild (≤1 day PTA)		80%	78%	80%	82%	71%	100%	100%
Mod/Severe (>1 day PTA)		100%	79%	84%	73%	67%	50%	67%
χ^2 (*df*)		8.29 (1)	.003 (1)	1.25 (1)	.	.		
p		**.004**	.96	.72	.69	1.00		

Note. [a] Fishers Exact test was used, in accordance with McPherson (1990), because *n* < 40, or at least cell has an expected count < 3

Table 8.6

Information on Hospitalisation for Separate Disciplines

Percent hospitalised	Total Sample	Nursing	Psychology	Physiotherapy	Occupational Therapy	Social Work	Speech Pathology	Dietetics
Referrals	*N* = 175	*n* = 152	*n* = 137	*n* = 58	*n* =50	*n* = 45	*n* = 12	*n* = 4
Not Hospitalised	82 (47%)	92%	81%	23%	20%	27%	4%	1%
Hospitalised	93 (53%)	83%	76%	42%	37%	25%	10%	3%
χ^2 (*df*)		2.87 (1)	0.44 (1)	6.93 (1)	6.21 (1)	.10 (1)		
p		.090	.51	**.009**	.013	.75		
Appointments		*n* = 83	*n* = 109	*n* = 51 [a]	*n* = 33	*n* = 26	*n* = 8	*n* = 4
Not Hospitalised		61%	80%	90%	63%	68%	33%	100%
Hospitalised		48%	79%	87%	68%	48%	79%	100%
χ^2 (*df*)		2.70 (1)	.04 (1)		.13 (1)	1.91 (1)		
p		.100	.84	1.00	.720	.17		
Attendances		*n* = 73	*n* = 85	*n* = 42	*n* = 25 [a]	*n* = 18 [a]	*n* = 6	*n* = 3
Not Hospitalised		83%	74%	82%	60%	73%	100%	100%
Hospitalised		95%	82%	82%	83%	64%	71%	67%
χ^2 (*df*)		2.78 (1)	1.16 (1)	.00 (1)				
p		.095	.28	1.00	.21	.68		

Note. [a] Fishers Exact test was used, in accordance with McPherson (1990), because *n* <40, or at least one cell has an expected count <3

In summary, the findings for injury-related variables were:

- Increased service utilisation, as measured by the number of clinical disciplines participants were referred to, was associated with increased severity of injury (p = .006).
- There was a trend towards an association between increased service utilisation and a history of previous TBI (p = .041).
- Participants with moderate to severe injuries were more likely to be referred to Physiotherapy (p = .003) and Occupational Therapy (p = <.001) than those with mild injuries.
- Participants who had been admitted to hospital were more likely to be referred to Physiotherapy than those who had not been hospitalised following their injury (p = .009).
- Participants injured in an assault-related TBI were more likely to be referred to Psychology than those injured in a transport-related accident (p=.004).
- There was a tendency for more of the hospitalised sample (p = .013), and for more of those injured in a fall, compared with assault-related injuries (p=.013), to receive a referral for Occupational Therapy.
- There was a tendency for those with a history of previous TBI to be referred to Psychology (p = .035), and for Nursing to offer more appointments (p = .049) to those who had experience a previous TBI, compared with those who had no history of TBI.
- All moderate or severe injuries offered appointments or HVs in Nursing attended them, compared with 80% of mildly injured participants offered Nursing appointments or HVs (p = .004).

8.4 Discussion

As reviewed in chapter 3 a large amount of research has found an association between increasing injury-severity and poorer outcomes across a range of outcome measures. It was therefore hypothesised that those with more severe injuries would be greater consumers of rehabilitation services. This could be reflected in greater access to the service (service utilisation) through referral to a greater number of disciplines and/or higher intensity of use, reflected in greater number of hours of therapy. The present study looked at service utilisation and its results support the hypothesis: Moderate and severe injuries were referred to more disciplines than mild injuries. This result is consistent with a number of studies of service utilisation post-TBI which have found that utilisation of most services increases as a function of severity of injury (Brooks, et al., 1995; High Jr, et al., 1995; Hodgkinson, et al., 2000).

It is important to note that, although participants with mild injuries were referred to fewer of CRU's clinical disciplines, the current study did not provide evidence that those with milder injuries had less engagement with CRU's clinical services overall. Intensity of service also needs to be considered. This will be investigated in study 5 which looks at amount of therapy participants received during their rehabilitation at CRU. In the current study, increased injury-severity was also associated with referral to Occupational Therapy and Physiotherapy, but more severely injured participants were not more likely to be offered an appointment in these disciplines, or in any other disciplines. In Nursing those with more severe injuries were more likely to attend appointments, which may reflect follow-up by HV of those with severe injuries by the rehabilitation nurses at CRU.

In previous research, use of psychological services has been found to be inversely related to injury-severity: Those with milder injuries access these services more frequently than more severely injured participants (High Jr, et al., 1995). In the present study the hypothesised association between milder injury and referral to Psychology was not sustained. This may be because the role of education and reassurance, which has been shown to be particularly beneficial in mild injuries (Alves, et al., 1993; Wade, et al., 1997; Wade, et al., 1998), was shared with the discipline of Nursing. As discussed in study 2, both Nursing and Psychology received referrals for a large proportion of the whole sample, with a range of injuries from mild to severe. Nursing did receive referrals for a larger proportion of mild, compared with moderate to severe injuries, but this difference was not statistically significant. Psychology, on the other hand, received referrals for a similar proportion of mildly injured participants (79%) and moderately to severely injured participants (77%). This may be because of the diverse range of assessments and interventions which the discipline of Psychology was performing at CRU. Forty four (32%) of those referred received a neuropsychological assessment indicating that some referrals would have been for this service as well as, or instead of, services provided by clinical psychology, such as cognitive behavioural therapy and counselling.

Given that a history of previous TBI has been shown to be a predictor of worse outcomes (Ewing, et al., 1980; Gronwall & Wrightson, 1975; Ponsford, et al., 2000; Thornhill, et al., 2000), it was hypothesised that those with a previous TBI would be referred to more disciplines at CRU, compared with those who had not previously suffered a head injury. The results of the present study show that this was the case, but the difference only approached statistical significance (p = .041). There was also non-significant trends towards those with a previous TBI being referred to Psychology (p = .035), and towards Nursing (p = .049) offering more appointments to participants who had suffered a previous TBI than those who had no history of previous brain injury.

Nursing was often the initial point of contact with the service and the liaison between the brain injury clinic and the rehabilitation services provided by CRU. Nursing therefore may have been ensuring follow-up for this sub-sample of patients who are at risk for poor outcomes, one aspect of which may have been referral to Psychology. On the other hand, it may be that those who have had a previous TBI have more serious injuries or more presenting problems resulting in referral to more services. In order to ascertain if participants in the current study who had experienced a previous TBI, had more severe injuries than those without a history of TBI, post hoc analyses were performed to compare the two groups for injury-severity. The results, further details of which can be found in Appendix U, indicated that there was no statistically significant difference in their mean PTA or in the percentage of injuries that could be classified as mild according to the ACRM's definition. However it is possible that there may be differences in other-system injuries that the groups sustained. There is also evidence to suggest that individuals who have suffered a previous TBI may have more difficulties following a mTBI, than patients with no previous TBI history (Ewing, et al., 1980; Ponsford, et al., 2000), which may mean that they would require more services.

Assaults caused the largest proportion (39%) of injuries in the whole sample. As discussed in study 1, transport-related accidents typically form the greatest proportion of injuries in most epidemiological studies (Kraus, Peek-Asa, & McArthur, 2000; Tagliaferri, et al., 2006; Tate, et al., 1998) and only a small proportion of TBI is from assault-related injuries. The large proportion of assault-related TBI in the present study is partly a result of the disproportionate number of TBI patients injured in motor vehicle accident who access privately funded rehabilitation services, and were therefore not included in the present sample. It is also a result of the referral of a large number of assault-related TBI cases by TNTR. Without the presence of the TNTR project most, of these individuals would probably not have been referred for rehabilitation, because, as discussed in study 1 only a small percentage (23%) had been hospitalised following their injury, and assault-related cases had suffered milder injuries than those incurring their TBI from other cause. The high levels of PCS, pain, fatigue and psychological symptoms which the TNTR group were reporting, however, are consistent with the poorer outcomes that previous research has found to be associated with violence-related TBI (Gerhart, et al., 2003; Hanlon, et al., 1999; Wenden, et al., 1998b).

Because violence-related TBI has been associated with more PCS and poorer cognitive outcomes, it was hypothesised that participants whose injury was caused by an assault would be referred to more clinical disciplines. This hypothesis was not supported. However there was a relationship between TBI caused by assault and the pattern of service utilisation: Those who had been injured in an assault had a higher probability of being referred to Psychology than those injured in a transport related accident. It may be that a proportion of those with assault-related injuries had psychological difficulties associated with the injury. Also some may have had premorbid psychopathology or interpersonal problems which may have been the cause of their violence-related TBI, and referral to Psychology may have been for assistance with these premorbid problems. The relationship between service use, and anxiety and depression, as measured by the HADS will be examined in study 4 in chapter 9.

As outlined in study 1 the initial face-to-face contact for almost half (44%) of participants seen by the discipline of Nursing was in the form of a HV. Other disciplines also conducted HVs but the proportion of those referred receiving them was much lower: For example Social Work, saw 28% of participants in their homes and Occupational Therapy saw 12%. Also, other disciplines were more likely to see participants in their homes during the course of therapy, rather than for an initial assessment. As discussed previously, the discipline of Nursing at CRU provided initial support and education to TBI patients and was the liaison between the brain injury clinic and the rehabilitation services provided by CRU. By conducting a significant proportion of initial assessments in a home visit, Nursing was in a position to follow-up those who may have had difficulty attending appointments at CRU. The fact that all those with moderate-to-severe injuries offered appointments in Nursing attended them, may reflect follow-up by Nursing, by HV when necessary, of those with more severe injuries. Additionally, it may be that participants viewed an appointment with Nursing in a different light to appointments with allied health disciplines because of the association with the brain injury clinic and the rehabilitation physician. They may have seen those appointments as more important than, for example, an appointment with Psychology.

Hospitalisation following TBI may be due to the head injury, to injuries to other parts of the body, for example orthopaedic injuries, or a combination of the two. The few prognostic studies which have looked at hospitalisation as a variable have found that more PCS and poorer functional outcomes were experienced by those who had been admitted to hospital (Lowdon, et al., 1989; Wenden, et al., 1998b). It was therefore hypothesised that hospitalisation would be associated with increased range of service utilisation. The results of the present study indicate that hospitalisation was not associated with increased service utilisation, as measured by the number of disciplines participants were referred to. However it was associated with referral to Physiotherapy (p = .009) and there was a trend towards Occupational Therapy receiving more referrals from hospitalised participants, which was verging on statistical significance (p = .013). Individuals who have experienced a TBI in the more severe end of the spectrum might be more likely to experience other significant injuries such as fractures or soft tissue injuries needing treatment in hospital, and possibly a period of outpatient rehabilitation care in disciplines such as Physiotherapy and Occupational Therapy. The role of these two disciplines is to facilitate physical recovery, maximise function and independence and, in the case of Occupational Therapy in particular, remove barriers that prevent participation in social, vocational or recreational activities. Study 5 will investigate if hospitalisation was associated with increased service intensity in these disciplines, as measured by the amount of therapy participants received.

As outlined in chapter 5, Occupational Therapy is indicated where a person's health condition limits their ability to carry out activities of everyday life. A proportion of those injured in falls would be expected to have suffered orthopaedic injuries for which they would need assistance from Occupational Therapy to modify their environment, or provide extra support to enhance their ability to participate in the activities of everyday life. Those with fractures may also have been referred to Physiotherapy for assistance with regaining full range of movement and muscle strength. It was noted in study 2 that those who were older were more likely to be referred to Physiotherapy. As fall-related TBI is more prevalent in older adults (Kinsella, 2011; Kraus, et al., 1984), and those who were older were more likely to be referred to Physiotherapy and Occupational Therapy, a question from that study was whether those injured in a fall would be more likely to be referred to these disciplines in the current study. In the present study an association between referral to Physiotherapy and fall-related TBI was not found, but Occupational Therapy did tend to receive more referrals for those injured in a fall. As reported in table 8.3, a chi-square analysis looking at the three main causes of injury and referral to Occupational Therapy found there were differences tending towards significance ($\chi^2(2) = 6.18$, $p = .045$). Post hoc analyses found an association between falls and referral to Occupational Therapy that was verging on significance, compared with those injured in an assault, $\chi^2(1) = 6.21$, p=.013, but no significant difference was found compared to transport-related injuries. The reason those injured in a fall were not more likely to be referred to Physiotherapy at CRU may be because a proportion of those needing physiotherapy for orthopaedic injuries may have been referred to see a physiotherapists at their local community health centre, particularly those who were older and had difficulties travelling for appointments. Occupational therapy services, however, are not so available in community settings and TBI patients requiring an occupational therapy intervention may therefore have been referred to this discipline at CRU.

8.4.1 Summary and research directions.

This study has provided indications of some of the injury-related variables that may have influenced the clinical services accessed by the sample of TNTR patients referred to CRU for rehabilitation following their injury. Increased severity of injury and previous TBI, which have both been shown in numerous studies to be associated with poorer outcomes across a range of measures, were associated with referral to more disciplines at CRU, although for previous TBI this association was only approaching statistical significance. This finding is consistent with studies of service-use post-TBI which have shown that increased severity is associated with use of more services. However a period of hospitalisation post-injury, which previous research has shown to be associated with poorer outcomes, was not associated with referral to more clinical disciplines at CRU.

One of the questions raised in the first study was whether the group of mildly-injured participants referred by TNTR would engage with CRU's clinical service and a question from study 2 was whether those with milder injures were more likely to be referred to fewer disciplines, and if so were they mainly referred to the disciplines of

Nursing and Psychology (for education and reassurance)? The results of the current study indicated that those with milder injuries were referred to fewer disciplines, and there was a slight tendency for milder injury to be associated with referral to Nursing, but no difference found for Psychology referrals. As discussed in study 2, both Nursing and Psychology received referrals for a large proportion of the whole sample, with a range of injuries from mild to severe and it is likely that both disciplines were providing education and reassurance to those with milder injuries.

Furthermore it is not clear if referral to fewer disciplines equates to less engagement with CRU's services. An answer to this question will depend partly on how much therapy they received in the discipline or disciplines they were referred to, and partly on their response to therapy: It may be that those with milder injuries had less need for therapy. The amount and nature of therapy participants received will be investigated in Study 5 of this thesis. Assessment of participants' response to therapy, however, requires measurement of outcome which is beyond the scope of the current research.

Nursing was more likely to give appointments to those with previous TBI, possibly reflecting follow-up of those at risk for poorer outcomes. The 100% attendance of initial appointments in Nursing by those with more severe injuries may be due to the practice of performing initial assessments in the injured person's home rather than asking them to attend an outpatient appointment. Assault-related TBI has also been shown to be associated with poorer outcomes. In this study those injured in an assault were not referred to more of CRU's disciplines, but they were more likely to be referred to Psychology. This may have been for assistance with pre-morbid difficulties which may have caused the injury, or assistance with problems resulting from it. Those who had been hospitalised were more likely to receive a referral to Physiotherapy and an association with referral to Occupational Therapy and hospitalisation was verging on significance. There was a tendency for those injured in a fall to be referred to Occupational Therapy, but not to Physiotherapy. This may reflect the greater availability of physiotherapy for orthopaedic injuries, compared to occupational therapy, in community health centres.

Study 4, described in the next chapter, will consider how a range of post-injury variables in the current TBI sample were related to their initial progress in therapy at CRU.

In developing a model of pathways of rehabilitation, which is one of the overall aims of the current research, the results of the current study suggest it will be important to note the following factors:

- Follow-up of TBI patients with assaults may require more input from Psychology, than from more traditional rehabilitation disciplines such as Physiotherapy and Occupational Therapy.
- Follow-up in the community, through HVs, may be useful for those with more severe injuries, or a history of previous TBI, who may have cognitive impairments such as memory or executive deficits, that may be barriers to engagement in therapy.

CHAPTER 9 - Study 4: The relationship between post-injury variables and initial contact with CRU's clinical services

As described in chapter 2 a large number of factors have been shown to influence outcome following TBI. Studies 2 and 3 considered some of the demographic and injury-related characteristics of the TNTR sample referred to the Community Rehabilitation Unit (CRU), and looked at how those characteristics were related to their initial contact with the service. The present study looks at some indicators of the sample's post-injury functioning and status (post-concussion symptoms (PCS), symptoms of anxiety and depression and measures of functional status), and considers how these factors relate to their referral to CRU's seven clinical disciplines, the probability of being offered an appointment in one or more of them, and the probability of attending when offered one.

As reviewed in chapter 3, PCS are a constellation of physical, cognitive and emotional symptoms, which occur after a mild head injury as well as after moderate and severe injuries. The ones most commonly reported are headaches, fatigue, memory problems and sleep difficulties. (Carroll, et al., 2004b). Outcome studies indicate that, although PCS are largely resolved in three months in most people with mTBI, a significant minority continue to report symptoms at 6 and 12 months post-injury. Female gender, a history of pre-existing physical limitations, prior TBI, litigation and compensation issues, neurological or psychiatric problems and older age have all been identified as possible predicators of persistent symptoms, but confirmatory studies are needed.

Psychiatric problems are common following TBI of all severities, and may be due to premorbid problems or a direct result of the injury. Prevalence rates for depression are higher than anxiety, but this may be because anxiety symptoms are often overlooked or assumed to be a normal reaction to the injury. Psychiatric problems are associated with poorer outcomes for TBIs of all severities. In particular, major depression is associated with poorer social functioning for all severities, while anxiety has been shown to be predictive of persistent PCS (King, 1996; Mooney & Speed, 2001). As outlined in chapter 5, an Australian study of service utilisation (Hodgkinson, et al., 2000), in a sample of 119 severely injured TBI patients, found that the prevalence of mental illness increased from less than 1% pre-injury to 16% post-injury. This study compared service-use in four groups at different times post-injury (6—18 months, 2—4 years, 6—9 years, and 10—17 years) and found that the nature of services accessed differed over time, with those in the first four years post-injury tending to use services which focused on restoration of function, adjustment to disability and community integration. Additionally, this study found that participants with a history of mental illness post injury had attended fewer medical and allied health appointments in the 12 months prior to being interviewed compared with those who had not experienced mental illness following their TBI.

The spectrum of dysfunction following TBI ranges from severe physical incapacity and handicap to severe cognitive and psychological difficulties. Recovery extends over a long time period following more severe TBI, and the profile of difficulties encountered often changes: physical difficulties predominating initially but cognitive and behavioural difficulties becoming increasingly important over time. Rehabilitation measures, such as the Functional Independence Measure (FIM; Corrigan, et al., 1997) designed to assess this wide range of difficulties have been found to predict outcomes such as employment and life satisfaction.

9.1 Aims and Hypotheses

The present study aimed to examine how PCS (as measured by the RPQ), symptoms of anxiety and depression (as measured by the HADS) and functional independence (as measured by the FIM) were related to the TNTR sample's referral to CRU's seven clinical disciplines, how they impacted on the probability of their being offered an appointment in those disciplines and, for the cohort who were offered appointments, the probability of their attending them. The relationship between these post-injury variables and service utilisation, as measured by the number of disciplines participants were referred to, was also examined.

Based on research reviewed in chapters 3 and 4 of this thesis and summarised above it was hypothesised that:

- Participants with moderate to severe levels of PCS would be more likely to be referred to the disciplines of Nursing for assistance with these symptoms than those with minimal to mild levels of these symptoms.
- Participants with less than a maximum score on the FIM, indicating some level of functional dependence, would be referred to more disciplines than those with maximum scores on this measure.
- Participants with less than a maximum score on the FIM, indicating some level of functional dependence, would be more likely to be referred to the disciplines of Physiotherapy and Occupational Therapy, than those whose scores on the FIM indicated complete functional independence.
- Participants with moderate to severe symptoms of anxiety would be more likely to be referred to the discipline of Psychology than those in the normal to mild category.

- Participants with moderate to severe symptoms of depression would be more likely to be referred to the discipline of Psychology than those in the normal to mild category.

9.2 Method

9.2.1 Participants.

All participants for this study were individuals who had consented to be part of the Tasmanian Neurotrauma Register (TNTR) research project following a TBI. This project has been described in more detail in chapter 5. As described in study 2, eligibility criteria for the present study were individuals on the TNTR who had been referred to CRU for rehabilitation and whose treatment was provided by CRU clinicians. A total of 175 individuals were included in the present study. The demographic characteristics of the sample are outlined in study 2, and the injury-related characteristics are outlined in study 3 of this thesis.

The post-injury characteristics of the sample related to this study are outlined in table 9.1 below. The interpretation of Hospital Anxiety and Depression Scale (HADS) scores suggested in the manual (Zigmond & Snaith, 1983) was used to characterised the participants' anxiety and depression as normal to mild (0—10) or moderate to severe (> 10). Post-concussion symptoms (PCS) were measured using the Rivermead Post-concussion Symptoms Questionnaire (RPQ: King, et al., 1995) and the classification (0—12 = minimal, 13—24 = mild, 25—32 = moderate and above 32 = severe levels of symptoms) suggested by Potter et al (2006) was used to characterise participants as having minimal to mild (0—24) or moderate to severe PCS (> 24). Participants' level of functional independence was assessed using the Functional Independence Measure (FIM; Corrigan, et al., 1997) and they were divided into those who had a maximum score of 126, indicating complete functional independence on all items, and those who had a lower score, indicating some level of dependence.

As outlined in study 1, (chapter 6) data were missing for some participants on one or more of the measures in this study. There were a variety of reasons for this, such as refusal by some participants to complete some questionnaires, missing data on individual items on some questionnaires rendering the scale-score invalid, and the inability of some participants to complete all questionnaires at their initial assessment because of factors such as fatigue, or PCS.

Table 9.1
Post-injury Characteristics of the Whole Sample

Post-concussion symptoms (RPQ) (*N* = 165)		Anxiety (HADS) (*N* = 157)	
Mean RPQ Score	30.46 (14.61)	Mean Anxiety	10.69 (5.72)
Range	0-64	Range	0 - 21
Median	33.00	Median	11
Minimal to mild PCS	58 (35%)	Normal to mild	74 (47%)
Moderate to severe PCS	107 (65%)	Mod. to severe	83 (53%)
Functional Independence (FIM) (*N* = 166)		**Depression (HADS) (*N* = 157)**	
Mean FIM score	121.13 (11.27)	Mean Depression	7.88 (4.87)
Range	18 - 126	Range	0 - 21
Median	124	Median	8
Not-independent	103 (62%)	Normal to mild	112 (71%)
Independent	63 (38%)	Mod. to severe	45 (29%)

9.2.2 Clinical disciplines.

Seven clinical disciplines were operating at CRU during the period of this study: Nursing, Physiotherapy, Occupational Therapy, Social Work, Psychology, Speech Pathology and Dietetics. Further details of the operation of these clinical disciplines during the period of this study have been outlined in chapters 5 and 6.

9.2.3 Instrumentation.

The following measures, all of which have been described in more detail in chapter 3 of this thesis, were used in this study:

- **Rivermead Post-Concussion Symptoms Questionnaire** (RPQ; King, et al., 1994) is a measure of the severity of post-concussion symptoms.
- **Hospital Anxiety and Depression Scale** (HADS; Zigmond & Snaith, 1983) is a self-assessment scale, developed to assess levels of anxiety and depression in physically ill patients in inpatient and outpatient settings.
- **Functional Independence Measure** (Corrigan, et al., 1997) is a well-researched measure of functional independence for use in TBI rehabilitation.

9.2.4 Design.

This study used a cross-sectional design, with adults who had sustained a TBI and had been referred for rehabilitation to CRU. Data on the variables of PCS (RPQ scores), functional independence (FIM scores) and anxiety and depression (HADS scale scores) were collected during the TNTR assessment, at the time-point at which they were referred, or the closest one before their referral, in order to investigate their role in relation to referral for rehabilitation and initial contact with CRU's clinical services. Information about participants' referral to CRU and to its clinical disciplines was obtained from CRU clinical files.

9.2.5 Procedure.

The procedure followed in this study, including the method of obtaining informed consent, was identical to that used in study 2 (see chapter 6).

In addition the following data for each participant's TBI was obtained from assessments performed at the TNTR:

- Post-concussion symptoms (RPQ scores)
- Anxiety (Scores on the HADS anxiety scale)
- Depression (Scores on the HADS depression scale)
- Functional Independence (FIM score)

For the purpose of this study scores collected at the time-point at which participants were referred, or the closest one before their referral, were used. For example, for those referred between three and five months, the three-month data were used. If data were missing for a participant at the time-point at which he or she was referred, then scores from the previous time-point data were used. If that was also missing a score was not calculated for that participant.

Participants were divided into two groups, for each of the four variables examined in this study, according to their scores on the four measures, categorised as follows:

Post-concussion symptoms (RPQ)	Minimal to mild / Moderate to severe
Functional independence (FIM)	Independent / Not-independent
Anxiety (HADS)	Normal to mild / Mod to severe
Depression (HADS)	Normal to mild / Mod to severe

The criteria used for this categorisation are described in the "method" section.

9.2.6 Analyses.

Chi-square analyses were used to explore the impact of the variables of anxiety, depression, PCS and functional independence on service utilisation, by comparing the percentage of participants referred to ≤ 2 disciplines with the percentage referred to > 2 disciplines for each variable. Chi-square analyses were also used to explore the impact of the same variables on referral to CRU's five largest disciplines, Nursing, Psychology, Physiotherapy, Occupational Therapy and Social Work, on the likelihood of participants being offered an appointment or a HV in each of those disciplines and, for those who were offered an appointment, to the likelihood of their attending it. These tests were not performed for the disciplines of Speech Pathology and Dietetics, because of the small samples referred to those disciplines.

9.3 Results

The results of this study are presented in two sections. The first section looks at service utilisation, as measured by the number of clinical disciplines participants were referred to, and considers how the variables of PCS, anxiety, depression and functional independence are related to it. The second section looks at how these demographic variables relate to participants' referral to each of the CRU clinical disciplines, to the probability of their being offered an appointment or home visit (HV) in a discipline and to the probability of their attending an appointment/receiving a home visit if offered one.

9.3.1 Referrals to CRU clinical disciplines.

Details of the total numbers of CRU disciplines study participants were referred to are presented in table 7.5 in chapter 7.

Table 9.2 displays the results of chi-square analyses of study variables on service utilisation, as measured by the number of disciplines participants were referred to: there were no statistically significant differences. There was a slight tendency for those who were dependent on the FIM be referred to more disciplines, but this failed to reach statistical significance (p = .07).

Table 9.2
Effect of Functional Independence, PCS, Anxiety and Depression on Service Utilisation

	> 2 disciplines	*n*	$\chi 2$	*df*	*p*
FIM (*n* = 166)					
Independent	38%	24	3.22	1	.07
Not-independent	52%	54			
PCS (RPQ) (*n* = 165)					
Minimal to mild	43%	25	0.62	1	.43
Moderate to severe	50%	53			
Anxiety (HADS) (*n* = 157)					
Normal to mild	46%	34	0.03	1	.86
Moderate to severe	45%	37			
Depression (HADS) (*n* = 157)	42%	47	1.68	1	.19
Normal to mild	53%	24			
Moderate to severe					

9.3.2 Initial contact with clinical disciplines.

Table 7.5 in chapter 7 of this thesis shows the number and percentage of the sample referred to each discipline, the number and percentage of referrals offered an initial appointment, or HV, by each discipline and the number and percentage of those offered an appointment or HV who attended it. As outlined in chapter 7 HVs were conducted in the disciplines of Nursing, Social Work, Occupational Therapy and Psychology.

For five of the seven disciplines, chi-square analyses were used to compare the groups referred to each discipline; those offered an appointment or home visit and those who attended appointments, on the post injury variables of functional independence, PCS, anxiety and depression. Due to the small numbers in the samples referred to Speech Pathology and Dietetics analyses were not performed for these disciplines.

9.3.2.1 Post-concussion symptoms (PCS).

Chi-square analyses for PCS, as measured by the RPQ, are presented in table 9.3. No statistically significant differences were found, but there was a strong tendency for those with moderate to severe PCS to be referred to Nursing more frequently than those with milder symptoms (p = .013). There was also a strong tendency for Occupational Therapy to receive more referrals from those with minimal to mild PCS, than from those with moderate to severe symptoms (p = .019).

9.3.2.2 Functional independence.

Table 9.4 gives chi-square analyses for functional independence for each of the disciplines. A larger percentage of those who were not functionally independent, as measured by the FIM, were referred to Occupational Therapy, than those who were functionally independent, and this verged on statistical significance (p = .011)

9.3.2.3 Anxiety (HADS).

Chi-square analyses for symptoms of anxiety reported on the anxiety sub-scale of the HAD are presented in table 9.5. A larger percentage of those with anxiety scores in the normal to mild range, were referred to Occupational Therapy, than those with scores in the moderate to severe range, with this difference approaching significance (p = .016).

9.3.2.4 Depression (HADS).

Table 9.6 gives chi-square analyses for symptoms of depression reported on the depression sub-scale of the HADs. A larger percentage of those with depression scores in the moderate to severe range, were referred to Social Work, than those who with scores in the normal to mild range, although this tendency did not reach significance ($p = .025$).

The following is a summary of the post-injury characteristics of the samples referred to different disciplines:

9.3.2.5 Nursing.

Nursing received a larger proportion of those reporting moderate to severe levels of PCS than those with fewer PCS, this difference verging on statistical significance ($p = .013$).

9.3.2.6 Occupational therapy.

There was a tendency for Occupational Therapy to receive referrals for more participants reporting normal to mild levels of anxiety and minimal to mild levels of PCS, than those reporting higher levels of anxiety and PCS, these differences being very close to significance ($p = .016$ and $p = .019$ respectively).

9.3.2.7 Social work.

There was a tendency for Social Work to receive referrals for more participants reporting moderate to severe levels of depression, than those reporting depressive symptoms in the normal to mild range, although this differences did not reach significance ($p = .025$).

9.3.2.8 Other disciplines.

No significant differences were found in the other clinical disciplines for any of the post-injury variables examined in this study.

Table 9.3

Information on Post-concussion Symptom (RPQ) for Separate Disciplines

	Total Sample	Nursing	Psychology	Physiotherapy	Occupational Therapy	Social Work	Speech Pathology	Dietetics
Referrals	*N* = 170	*n* = 145	*n* = 128	*n* = 54	*n* = 47	*n* = 43	*n* = 11	*n* = 4
Minimal/mild PCS	78 (46%)	80%	72%	35%	40%	17%	9%	2%
Mod/severe PCS	92 (54%)	93%	80%	38%	22%	30%	5%	3%
χ^2 (*df*)		6.17 (1)	1.37 (1)	1.10 (1)	5.48 (1)	3.18 (1)		
p		.013	.24	.29	.019	.075		
Appointments		*n* = 78	*n* = 105	*n* = 47 [a]	*n* = 32	*n* = 25	*n* = 7	*n* = 4
Minimal/mild PCS		46%	83%	77%	65%	60%	60%	100%
Mod/severe PCS		58%	81%	93%	71%	56%	80%	100%
χ^2 (*df*)		1.80 (1)	.07 (1)		.17 (1)	.04 (1)		
p		.18	.79	.107	.68	.83		
Attendances		*n* = 68	*n* = 82	*n* = 39	*n* = 24	*n* = 17 [a]	*n* = 6	*n* = 3
Minimal/mild PCS		95%	80%	82%	87%	50%	67%	100%
Mod/severe PCS		84%	77%	83%	65%	78%	100%	67%
χ^2 (*df*)		1.67 (1)	0.11 (1)	0.07 (1)				
p		.19	.74	.93	.23	.31		

Note. [a] Fishers Exact test was used, in accordance with McPherson (1990), because *n* <40, or at least one cell has an expected count < 3.

Table 9.4

Functional Independence (FIM) Information for Separate Disciplines

	Total Sample	Nursing	Psychology	Physiotherapy	Occupational Therapy	Social Work	Speech Pathology	Dietetics
Referrals	*N* = 166	*n* = 146	*n* = 129	*n* = 55	*n* =48	*n* = 43	*n* = 12	*n* = 4
Independent	62	84%	71%	27%	18%	22%	6%	3%
Not-independent	104	90%	82%	37%	36%	27%	8%	2%
χ^2 (*df*)		1.40 (1)	2.31 (1)	1.73 (1)	6.48 (1)	.51 (1)		
p		.24	.13	.19	.011	.48		
Appointments		*n* = 80	*n* = 104	*n* = 48 [a]	*n* = 33	*n* = 24	*n* = 8	*n* = 4
Independent		51%	73%	82%	46%	50%	75%	100%
Not-independent		57%	86%	90%	76%	61%	63%	100%
χ^2 (*df*)		0.50 (1)	2.35 (1)		3.61 (1)	.44 (1)		
p		.48	.13	.66	.058	.51		
Attendances		*n* = 70	*n* = 83	*n* = 40	*n* = 25 [a]	*n* = 18 [a]	*n* = 6	*n* = 3
Independent		82%	73%	71%	100%	86%	100%	50%
Not-independent		91%	83%	88%	71%	71%	60%	100%
χ^2 (*df*)		1.35 (1)	1.50 (1)	2.01 (1)				
p		.25	.22	.16	.22	.41		

Note. [a] Fishers Exact test was used, in accordance with McPherson (1990), because n < 40, or at least one cell has an expected count < 3.

Table 9.5
Anxiety (HADS) Information for Separate Disciplines

	Total Sample	Nursing	Psychology	Physiotherapy	Occupational Therapy	Social Work	Speech Pathology	Dietetics
Referrals	N = 159	n = 136	n = 123	n = 49	n = 43	n = 37	n = 8	n = 4
Normal to mild anxiety	78 (49%)	85%	74%	37%	37%	18%	6%	3%
Mod to severe anxiety	81 (51%)	89%	82%	27%	19%	30%	4%	2%
χ^2 (df)		0.27 (1)	1.33 (1)	1.82 (1)	5.83 (1)	2.80 (1)		
p		.61	.25	.18	.016	.09		
Appointments		n = 75	n = 98	n = 42 [a]	n = 28	n = 22	n = 6	n = 4
Normal to mild anxiety		52%	80%	78%	63%	62%	80%	100%
Mod to severe anxiety		58%	79%	96%	69%	58%	67%	100%
χ^2 (df)		0.36 (1)	.01 (1)		0.15 (1)	0.04 (1)		
p		.55	.94	.09	.70	.85		
Attendances		n = 66	n = 77	n = 36	n = 20 [a]	n = 16 [a]	n = 5	n = 3
Normal to mild anxiety		91%	78%	81%	77%	63%	75%	100%
Mod to severe anxiety		86%	80%	91%	64%	79%	100%	50%
χ^2 (df)		0.47 (1)	0.08 (1)	0.78 (1)				
p		.49	.77	.38	.37	.37		

Note. [a] Fishers Exact test was used, in accordance with McPherson (1990), because n <40, or at least cell has an expected count < 3.

Table 9.6

Depression (HADS) Information for Separate Disciplines

	Total Sample	Nursing	Psychology	Physiotherapy	Occupational Therapy	Social Work	Speech Pathology	Dietetics
Referrals	*N* = 159	*n* = 133	*n* = 123	*n* = 49	*n* = 43	*n* = 37	*n* = 8	*n* = 4
Normal/mild dep.	114	84%	78%	30%	30%	19%	5%	4%
Mod/severe dep.	45	93%	80%	33%	22%	36%	4%	0%
χ^2 (*df*)		2.45 (1)	0.10 (1)	0.13 (1)	0.85 (1)	5.03 (1)		
p		.12	.79	.72	.36	.025		
Appointments		*n* = 75	*n* = 98	*n* = 42 [a]	*n* = 28	*n* = 22	*n* = 6	*n* = 4
Normal/mild dep.		49%	81%	82%	64%	48%	67%	100%
Mod/severe dep.		69%	79%	93%	70%	75%	100%	0%
χ^2 (*df*)		4.75 (1)	0.12 (1)		0.14 (1)	2.82 (1)		
p		.029	.74	.29	.71	.09		
Attendances		*n* = 66	*n* = 77	*n* = 36	*n* = 20 [a]	*n* = 16 [a]	*n* = 5	*n* = 3
Normal/mild dep.		87%	80%	86%	76%	70%	75%	75%
Mod/severe dep.		90%	75%	86%	57%	75%	100%	0%
χ^2 (*df*)		0.12 (1)	.30 (1)	.00 (1)				
p		.73	.59	.99	.30	.58		

Note. [a] Fishers Exact test was used, in accordance with McPherson (1990), because *n* <40, or at least cell has an expected count < 3.

In summary, the findings for post-injury variables were:

- Almost two thirds of participants were not functionally independent on referral for rehabilitation.
- Two thirds of particpants were reporting moderate to severe levels of PCS on their referral for rehabilitation.
- Fifty-three percent of the current sample was reporting moderate to severe levels of anxiety symptoms on their referral for rehabilitation, and 30% was reporting moderate to severe levels of depression.
- Increased service utilisation, as measured by the number of clinical disciplines participants were referred to, was not significant associated with any of the variables in this study, but there was a slight tendency ($p = .07$) for those with some level of dependence on the FIM to be referred to more disciplines.
- A larger percentage of those reporting PCS in the moderate to severe range were referred to the discipline of Nursing compared with those reporting lower levels of PCS. This difference was close to statistical significance ($p = .013$)
- A larger percentage of those with anxiety scores in the normal to mild range, and those reporting PCS in the minimal to mild range were referred to Occupational Therapy, than those with scores in the moderate to severe ranges of anxiety and PCS, with these differences verging on significance ($p = .016$ and $p = .019$ respectively).
- A larger percentage of those with some level of functional dependence, as measured by the FIM, were referred to Occupational Therapy, than those who were functionally independent, this difference being very close to significance ($p = .011$)

- A larger percentage of those with depression scores in the moderate to severe range, were referred to Social Work, than those who with scores in the normal to mild range, although this difference did not reach significance (p = .025)
- No differences were found between the samples offered and not offered an appointment or the samples that attended or failed to attend an appointment in any discipline. The variables examined were not significantly linked to the probability of being offered or of attending such an appointment.

9.4 Discussion

Almost two thirds of this study's participants were not fully functionally independent when they were referred to CRU for rehabilitation. However, the hypothesis that dependence on the FIM would be associated with increased service utilisation was not supported. This result may be due to the heterogeneous nature of the sample, which had a wide range of injury-severity, or it may be due to ceiling effects which previous research has identified in this instrument (Hall et al., 1996). Neurological impairments following TBI can affect functioning across physical, cognitive and psychosocial domains, and the level of impairment will dictate which services are necessary at which time. While physical impairments tend to predominate in the early stages of rehabilitation, particularly in severe injuries, psychosocial problems resulting from cognitive impairments cause the most long-lasting difficulties (Ben-Yishay, et al., 1987; Weddell, et al., 1980). Physical disabilities may require the assistance of physiotherapy and occupational therapy, cognitive disabilities may be assessed and assisted by psychology, while psychosocial problems could be helped by social work. In the present study, those with mild injuries, who were not hospitalised post-injury, but had some level of functional dependence, may only have needed a very brief intervention from one discipline, whereas those with more severe injuries may have required many months of acute rehabilitation followed by input from a number of clinical disciplines during their outpatient rehabilitation at CRU. Additionally, comorbid conditions, such as orthopaedic injuries may have affected the services needed, in a proportion of the sample.

It was hypothesised that those who were functionally dependent would be more likely to be referred to Physiotherapy and/or Occupational Therapy, the disciplines that assist patients to address physical limitations to functional independence. Physiotherapists assist with physical recovery by assessing diagnosing and treating disorders of human movement; Occupational Therapists work to remove environmental and other barriers to participation in society, through education and training/retraining, remedial techniques, compensation strategies and environmental adaption. Results of the present study did show a tendency for Occupational Therapy to receive more referrals for those with some level of functional dependence, but this was not the case for Physiotherapy.

The reason why Physiotherapy did not receive referrals for a larger proportion of those who had not achieved functional independence, and the result for Occupational Therapy was only approaching significance, may be that the present study looked at the overall FIM score and split the sample into those whose score indicated that they were completely independent and those who had some dependency on this measure. It did not consider individual items or the two domains—motor and cognitive functions—which the FIM has been shown to measure (Linacre, et al., 1994). As discussed previously, the cognitive sequelae of TBI often cause more long-term difficulties than the physical impairments. It may therefore have been the cognitive items that best distinguished between those who were functionally independent on this measure and those who were not. More than half of the current sample had mild injuries so many participants may have had no impairments in the FIM's physical items but have been prevented by cognitive difficulties from achieving complete functional independence. This could be further investigated by looking at FIM scores in the two domains, which was beyond the scope of the present study, because scores on individual FIM items were not available for analysis. However the FIM's ceiling effects (Cohen & Marino, 2000; Hall, et al., 1996) indicate that it may be more useful in an inpatient than an outpatient setting. Participants in this study referred to CRU were typically a number of months post-injury by the time they attended physiotherapy and occupational therapy appointments and for many of them, the FIM may have not been sensitive enough to distinguish, at that point post-injury, between those with physical and environmental difficulties and those without them.

More than half of the members of the current sample were reporting moderate to severe levels of anxiety symptoms on their referral to CRU, while 30% reported moderate to severe levels of depression. This is contrary to studies (for example Deb, et al., 1999) which have found anxiety to be more prevalent than depression following TBI. However, as reviewed in chapter 3, anxiety in this clinical group is often overlooked or assumed to be a normal reaction to trauma. Furthermore depression may be more of a problem in the long-term, compared with anxiety, as in many patients depressive symptoms do not begin for a number of months post-injury (Varney, et al., 1987). As indicated in study 2, three quarters of the current sample was referred in the first six-months, post-injury, which may explain their lower level of depressive symptoms.

The research reviewed in chapter 3 of this thesis, indicates that anxiety and depression are associated with poor outcomes in TBI of all severities. It was therefore hypothesised that those reporting levels of anxiety and/or depression in the moderate to severe range on the HADS would be more likely to receive a referral to Psychology for assessment and treatment of psychological symptoms by clinical psychologists. The results of the current study showed a trend (p = .025) towards those reporting moderate to severe depressive symptoms being referred to Social Work, suggesting a greater need for support and assistance with services in this group. Surprisingly however, no differences in referrals to Psychology were found for those reporting higher levels of either anxiety or depressive symptoms, compared with those with normal to mild levels.

One possible explanation for this is that many of those reporting milder levels of psychological distress may have also been referred to Psychology, for assistance with other problems or for a neuropsychological assessment. The discipline of Psychology at CRU comprised two services, clinical psychology specialising in prevention, diagnosis and treatment of serious psychological difficulties, and neuropsychology providing specialist assessment and intervention, for known or suspected neurological disorders. This is one reason why, in contrast with some of the other disinclines such as Physiotherapy, which received referrals for only a third of the whole sample, a large percentage (78%) was referred to Psychology. However it does not explain why 20% of those with scores in the moderate to severe range of depression and 18% of those with scores in the moderate to severe range of anxiety symptoms on the HADS were not referred to Psychology. It may therefore be that CRU's internal referral process did not take these problems into account, or did not see them as important targets for therapy.

When referrals were received at CRU they were processed at an intake meeting. As described in chapter 5, this was a meeting, held twice a week and attended by a senior clinician from each discipline, during which referrals were assessed and assigned to one or more clinical disciplines. The form (see Appendix V) for incoming referrals to CRU's service contained a section requesting the referral agent to tick the disciplines that the patient was to be referred to. Although changes could be made by the clinicians present at the intake meeting, initial referrals to clinical disciplines were frequently made on the basis of the boxes ticked. This was because no overall screening questionnaires were administered or assessments carried out prior to this intake meeting, and therefore assignment to a clinical discipline was usually made on the basis of the information contained in the referral form. Any baseline measurements of symptoms or problems to be addressed in rehabilitation were performed by individual disciplines after they received a referral. If the referral agent, responsible for an individual's referral to CRU for rehabilitation, had not ticked the box for referral to Psychology, or mentioned psychological difficulties on the referral form, the individual was unlikely to be referred to Psychology.

Varney et al. (1987) found that two thirds (92/120) of a sample of closed head injury patients met the DSM-III criteria for a diagnosis of major depression, but one third of this group (33/92) did not appear depressed during interview, and only 18% (14/92) spontaneously complained of depressive symptoms. Studies also indicate that symptoms of anxiety following TBI are often overlooked, or assumed to be normal reactions to trauma (Hiott & Labbate, 2002). This suggests that psychological symptoms may frequently go undetected by those referring TBI participants for rehabilitation. Furthermore, previous research indicates that clinical psychology is frequently not considered to be a core rehabilitation discipline: studies documenting service utilisation post TBI in USA (Phillips, et al., 2004) and in Australia (Hodgkinson, et al., 2000) found that traditional rehabilitation services such as physiotherapy, speech pathology and occupational therapy were accessed much more frequently that clinical psychology and counselling. This suggests that many clinicians may not consider psychological symptoms when making referrals for rehabilitation. If this was the case with the current sample, then there may have been no mention of psychological symptoms on the referral form and, because there was no screening process at the CRU intake meeting, some of those with high levels of anxiety and depressive symptoms would not have been referred for assistance with them.

This is problematic in multi-disciplinary settings, such as CRU, because although the co-existence of depression and other medical conditions is well recognised, research suggests that many health professionals fail to recognise it (Haggman, et al., 2004; Pignone, et al., 2002). Although TBI patients at CRU could be referred to a discipline at any stage in the rehabilitation process, clinicians in other CRU disciplines may not therefore have recognised that some of the patients referred to them were suffering from depression, and therefore not considered referring them to Psychology.

In contrast with the studies documenting service utilisation post-TBI cited in the previous paragraph, the discipline of Psychology at CRU received referrals for more than three quarters of the sample of TBI patients in the current study, and 11 individuals were referred only to Psychology. One possible factor in the referral of such a large proportion of the sample to Psychology is that the TNTR was primarily staffed by clinical psychology interns who may have been biased towards referring for psychological assistance, compared with other referral sources such as physicians on the neurosurgical or acute rehabilitation wards of the RHH. The results of Study 1 of this thesis did indicate that the sample referred by the TNTR were reporting high levels of anxiety and depression, whereas the sample referred by other sources had much lower levels of these symptoms. The participants referred by TNTR may have been referred to Psychology for assistance with these symptoms. Interestingly, however, while a comparison of the samples by referral source in study 2 failed to find a significant difference in the percentages of the sample referred by TNTR and the sample referred by other sources, who subsequently were referred to Psychology (as reported in table 7.4), there was a significant difference in the percentages of the two samples who received a neuropsychological assessment. Specific information about which participants were referred for neuropsychology and which were referred for clinical psychology in this study was not available, because the two disciplines were amalgamated in 2005. However information was available about the numbers of participants who actually received a neuropsychological assessment: 24% of the sample referred by TNTR research assistants received a neuropsychological assessment compared with 50% of those referred from other sources, χ^2 (2) = 8.46, p = .004 (details of this analysis can be found in Appendix W). Given that some of those referred for a neuropsychological assessment may not have attended the appointment, it may be that referral to Psychology from hospital and community sources was mainly for a neuropsychological assessment rather than assistance with psychological symptoms, while a substantial proportion of referrals from TNTR were for clinical psychology. This would be consistent with a study of service use in Australia which found that the rehabilitation discipline most frequently accessed was neuropsychology (Hodgkinson, et al., 2000). However, because there were no protocols in place in the RHH, or in the community, to assess TBI patients for anxiety, depression and other psychological difficulties, it is likely that some individuals who could have benefited from referral to Psychology were missed by referrers from these sources. These could have been hospitalised TBI patients who were not referred at all for rehabilitation. However it could also be that a percentage of those in the CRU-Other group had high levels of psychological distress, but this was not detected when they were referred to CRU and consequently they were referred for other difficulties to one or more of CRU's clinical disciplines, but not referred to Psychology.

Persistent PCS have been found to impair return to work and psychosocial functioning (Dikmen, et al., 1986; Dikmen, et al., 1989). Two thirds of the current sample was reporting moderate to severe levels of PCS on their referral to CRU. Results of the present study indicate that higher levels of PCS were not associated with referral to more of CRU's clinical disciplines. This may be because PCS, particularly when present in mild injuries, have been shown to respond well to educational interventions (Wade, et al., 1998) which can be brief in nature (Paniak, et al., 1998; Paniak, et al., 2000). This kind of educational intervention does not necessarily involve referral to more than one clinical discipline. At CRU it was often provided by Nursing. It was therefore hypothesised that this group would be more likely to be referred to Nursing for assistance with these symptoms and for education about TBI. The results of the current study did indicate that more of the group reporting higher levels of PCS were referred to Nursing, compared to those with lower levels, although the difference did not quite meet statistical significance (p = .013). Notably however, this group were not more likely to be offered an appointment. This may be because in a proportion of cases advice and assistance may have been provided by telephone contact only.

PCS are more commonly reported in mild injuries, but a proportion of those with moderate and severe injuries also experience them. While injury-severity is not a predictor of persisting symptoms, those with moderate to severe injuries tend to report more symptoms, or increased severity of symptoms over time (Gordon, et al., 2000; Sigurdardottir, et al., 2009). This is possibly because a lack of awareness of deficits in the early stages, or the predominance of comorbid injuries and physical incapacity, initially make PCS appear relatively minor problems. As acute comorbid injuries resolve and the reality of long-term deficits resulting from the TBI becomes more apparent, PCS may surface as ongoing irritants in everyday functioning. Those with severe injuries may not, therefore, have been reporting high levels of PCS when they were referred to CRU, but due to multiple other problems have been referred to a number of disciplines. In contrast a proportion of those reporting moderate to high levels of PCS would have been those with mild injuries, requiring only a brief intervention consisting of education and reassurance. This would account for the finding that high levels of PCS were not associated with referral to more of CRU's clinical disciplines.

A similar process may also account for the finding that Occupational Therapy, which the results of study 3 showed was more likely to receive referrals for moderate to severe injuries, received a larger proportion of referrals for those reporting normal to mild symptoms of anxiety in the current study. It may be that those with moderate to severe injuries had lower levels of anxiety than the cohort who had experienced mild injuries. A review of psychiatric conditions following TBI which attempted to establish causality, found convincing evidence for an association between TBI and mood and anxiety disorders, but failed to find evidence of a biologic gradient. The authors suggest that more severe TBI may be protective for some psychiatric disorders via mechanisms such as reduced insight or other direct effects on brain systems involved in the production of these disorders. (Van Reekum, Cohen, & Wong, 2000). Interestingly Occupational Therapy received a higher proportion of referrals for those with lower levels of PCS than those reporting more PCS, again possibly because of the predominance of more severe injuries in the referred group, for the reasons described in the previous paragraph. However, as outlined above, this difference was only approaching significance, (p = .019).

9.4.1 Limitations.

The current study did not look at separate items on the FIM or take into consideration the two domains—motor and cognitive—which Rasch Analysis (Linacre, et al., 1994) has identified. Consideration of these factors in future studies using the same sample could identify important information about referral patterns in community rehabilitation.

9.4.2 Summary and research directions.

The results of the current study indicate that almost two thirds of the whole sample had some degree of functional dependence on their referral to CRU, but the hypothesis that functional dependence would be associated with referral to more clinical disciplines was not supported. This may be because those with mild injures who were referred to only one or two disciplines may still have had some level of cognitive impairment preventing them from achieving complete functional independence on the FIM. There was a trend towards more of those who were not functionally independent being referred to Occupational Therapy services, compared with those who were functionally independent. More than half of the whole sample was reporting moderate to severe levels of anxiety and one third was reporting moderate to severe symptoms of depression. Surprisingly however, those reporting higher anxiety and/or depressive symptoms were not referred to more of CRU's clinical disciplines, or more likely to be referred to psychological services. Significantly, a proportion of those reporting levels of psychological distress in the severe range were not referred to Psychology at CRU, despite the fact that Psychology received referrals for 78% of the sample. This may be because CRU's intake process did not screen for symptoms of anxiety or depression, which previous research suggests may be overlooked in this patient group. Psychological symptoms may not have been mentioned on the CRU referral form, particularly in those referred by sources other than TNTR, who may not have recognised these symptoms or may not have seen them as criteria for referral for rehabilitation. Comparison of the sample referred to CRU by TNTR, with the sample referred from other sources, indicated that those referred from other sources and subsequently seen by Psychology may have been referred for a neuropsychological assessment, and not necessarily for assistance with psychiatric symptoms.

Two thirds of the sample was reporting moderate to severe levels of PCS on their referral to CRU. Higher levels of PCS were not associated with referral to more clinical disciplines, but those reporting them were more often referred to Nursing. This may be because PCS are more common in mild injuries, and have been shown to respond to a brief educational intervention, which at CRU was provided by the discipline of Nursing. Occupational Therapy services at CRU received a larger proportion of referrals for those reporting normal to mild symptoms of anxiety and minimal to mild levels of PCS than those who were reporting higher PCS and anxiety, although this failed to reach statistical significance. One explanation for this trend may be the fact that, as shown in study 3 in the preceding chapter, moderate-to-severely injured participants were more likely to be referred to Occupational Therapy than those with milder injuries. Previous research has shown that more severely injured TBI patients may not report high levels of PCS and psychological symptoms, particularly in the early stages of their injury, due to factors such as lack of insight, or the predominance of physical incapacities resulting from the TBI and comorbid conditions, such as orthopaedic injuries. No differences were found between the samples offered and not offered an appointment or the samples that attended or failed to attend an appointment in any discipline.

This study is the last of the three which have examined a range of demographic, injury-related and post-injury variables in relation to initial contact with CRU's clinical services. Study 5 will investigate further how rehabilitation services impact on TBI patients' recovery by looking at the amount and nature of therapy participants received in CRU's seven clinical disciplines, and considering how the range of variables examined in studies 2, 3 and 4 have impacted on this.

In developing a model of pathways of rehabilitation, which is one of the overall aims of the current research, the results of the current study suggest it will be important to note the following factors:

- Protocols developed to assist medical staff in acute settings identify rehabilitation need following TBI will be more effective if measures of PCS and psychological symptoms are included.
- Screening TBI patients for psychological symptoms, before assigning them to different clinical disciplines, may help to identify those with higher levels anxiety and depression, who may otherwise not be identified in the rehabilitation process.
- Those with more severe injuries may not report PCS in the early stages of their injury. However, as PCS may become an important issue at a later stage post-injury, it may be valuable to provide education for all TBI patients, rather than targeting only those who report high levels of PCS on presentation to medical services.

CHAPTER 10 - Study 5: The relationship between demographic, injury-related and post-injury variables and provision of therapy by CRU

The overall aim of the current research is to investigate patterns of referral to outpatient rehabilitation services in a population-based sample, and to describe factors related to provision of therapy in rehabilitation, for those referred to public community rehabilitation. Study 1 investigated which factors influenced referral to rehabilitation in the whole sample of TBI patients enrolled on the TNTR, and compared those referred for public rehabilitation at the Community Rehabilitation Unit (CRU) with those referred for private rehabilitation and those not receiving any rehabilitation. Subsequent studies focus on the sample referred in the public sector. Studies 2,3 and 4 investigated how a range of demographic, injury-related and post-injury-related variables were related to participants' referral to CRU's seven clinical discipline, their likelihood of being offered an appointment, and, when offered one, their likelihood of attending it. To investigate further how rehabilitation services impact on TBI patients' recovery the current study considers the amount and nature of therapy participants received during their period of rehabilitation at CRU.

10.1 Aims and Hypotheses

The present study aimed to measure the amount and nature of therapy participants received in CRU's seven clinical disciplines, and to consider how the range of variables examined in studies 2, 3 and 4 have impacted on this. A number of questions raised in previous studies will be addressed in this study.

10.1.1 Questions raised in previous studies.

Service use is commonly looked at in two ways: firstly whether or not a service is used at all (service utilisation) and secondly, how much a service is used (service intensity) (Duan, et al., 1983). Studies 2, 3 and 4 looked at whether increased service utilisation, as measured by the number of disciplines participants were referred to, was associated with a range of demographic, injury-related and post-injury variables. The results obtained indicated that increased service utilisation was significantly associated with severity of the injury. There was also a trend towards those with a history of TBI and those who were older (> 30 years) to be referred to more services. These results gave rise to the question; were these factors also associated with service intensity as measured by the overall amount of therapy received?

In study 3, hospitalisation was associated with referral to Occupational Therapy and Physiotherapy. This gave rise to the question; was hospitalisation also associated with increased service use, as measured by the amount of therapy participants received, in Occupational Therapy and Physiotherapy?

In study 4, participants with higher levels of depression were more likely to be referred to Social Work than those with lower levels of depressive symptoms, but were not more likely to be offered an appointment. This result gives rise to the question; were the participants with higher levels of depression who were referred to Social Work but did not receive an appointment in that discipline, followed up by Social Work with telephone therapy?

In study 2 it was noted that participants in some disciplines received some therapy in the form of home visits. In Nursing this was the initial contact for a significant portion of those referred to that discipline and the following question was raised; did contact by home visit, particularly initial contact, result in greater engagement with the service, as gauged by provision of more therapy?

These four questions will be addressed in the present study.

Based on the results of Studies 2, 3 and 4, and the research about predictors of outcome and TBI rehabilitation summarised in Chapter 3, it was hypothesised that:

- Injuries in the moderate to severe categories would be associated with more hours of therapy.
- Previous TBI would be associated with more hours of therapy.
- Some level of functional dependence, as assessed by the FIM, would be associated with more hours of therapy.
- Older age would be associated with more hours of therapy.
- HVs would be associated with increased hours of therapy.
- Those with scores in the moderate to severe range of the anxiety subscale of the HADS would receive more hours of therapy in Psychology, than those in the minimal to mild range.
- Those with scores in the moderate to severe range of the depression subscale of the HADS would receive more hours of therapy in Psychology, than those in the minimal to mild range.
- Those with a history of TBI would receive more therapy in Nursing (because they were more likely to be offered appointments) than those with no previous TBI.
- Increased severity of injury would be associated with higher levels of therapy in Nursing (because preceding studies indicated that those with more severe injuries were more likely to attend Nursing appointments than those with milder injuries).

10.2 Method

10.2.1 Participants.

All participants for this study were individuals who had consented to be part of the Tasmanian Neurotrauma Register (TNTR) research project following a TBI. This project has been described in more detail in chapter 5.

As described in study 2, eligibility criteria for the present study were individuals in the TNTR outcome study who had been referred to the CRU for rehabilitation and whose treatment was provided by CRU clinicians. A total of 175 individuals were included in the initial analysis for this study, but the main analyses were conducted on a sub-sample of 150 individuals who received some therapy at CRU—the other 25 were not included because they did not receive any therapy. The demographic characteristics of the whole sample are outlined in study 2 and other characteristics relating to their injury and their level of functioning post-injury are described in the Studies 3 and 4 of this thesis.

10.2.2 Design.

This study used a cross-sectional design, with adults who had sustained a TBI and had been referred for rehabilitation to CRU. Data on the variables of gender, age-at-injury, years of education, estimated premorbid IQ, cause of injury, previous TBI, injury-severity and hospitalisation were collected as soon as possible following participants' injury and emergence from PTA. Data on the variables of PCS, functional independence, anxiety and depression were collected during the TNTR assessment at the time-point at which each participant was referred, or the closest one before their referral. Data on the length and nature of therapeutic contact with clinicians at CRU were collected from CRU clinical files, on completion of each participant's episode of rehabilitation, in order to investigate the amount of therapy received and the impact of demographic, injury-related and post-injury variables upon it.

10.2.3 Instrumentation.

The following measures, all of which have been described in more detail in chapter 3, were used in this study:

- **Hospital Anxiety and Depression Scale** (HADS) (Zigmond & Snaith, 1983)
- **Rivermead Post-Concussion Symptoms Questionnaire** (RPQ; King, et al., 1994)
- **Functional Independence Measure** (FIM; Corrigan, et al., 1997)

10.2.4 Procedure.

Examination of the clinical notes for participants indicated that a proportion of the therapy received by most of them was in the form of telephone calls with clinicians. This form of therapeutic contact was sometimes by prior arrangement, whereby clinicians would call to check how the individual was progressing, and sometimes incidental to phone calls made for administrative purposes. In order to take this into account when looking at the number of hours of therapy participants received, telephone calls, where matters relating to the participant's therapy were discussed with the participants, or with relatives or carers, and documented in the clinical files, were counted as therapy telephone calls. Telephone calls made purely for administrative purposes, for example for arranging an appointment, were not included in this count.

Clinical files at CRU, for all participants, were examined to identify the CRU disciplines referred to, and for each discipline the following information was collected:

- The number of sessions of therapy provided
- The number of home visits

- The number of therapy telephone calls
- Time-in-days from referral to a discipline until first contact (by letter or phone call) by that discipline
- Time-in-days from referral to a discipline and the first appointment with a clinician from that discipline.

As all disciplines indicated that their therapy appointments were made on an hourly basis, one session of therapy was taken to be one hour. Physiotherapists reported that, at times, they may see more than one individual in one of these hourly intervals, but as each patient works on exercises individually, under group supervision, for the one-hour time-slot, this was still counted as an hour of therapy. After consultation with CRU clinicians, therapy conducted during a home visit (HV) was estimated to be an hour in duration and therapy telephone calls were estimated to be ten minutes. Hours of therapy were calculated, on this basis, for each discipline for all episodes of care related to the TBI for which participants were included in this research. For those participants who were seen by more than one discipline, total hours of therapy across disciplines were also calculated. For the purpose of these calculations three indices of therapy were used:

1. Telephone therapy calls in hours (TTC)
2. Face-to-face therapy in hours (FFT) (obtained by adding home visits and hours of therapy from CRU appointments)
3. Total therapy in hours (TT) (obtained by adding TTC and FFT together)

Twenty five participants, 14 % of the total sample, did not receive any therapy at all at CRU, although all but two were referred to at least one discipline, with the majority (*n* = 15) receiving referrals to two disciplines. Ten were given at least one appointment, which they either cancelled or failed to attend, and the rest were not offered appointments. In order to ascertain if wait-times from referral to first contact were a significant factor in participants not receiving therapy in individual disciplines, the mean time-in-days from referral to first contact in each of the disciplines was compared for the group who received therapy with the group that did not receive it. Results are presented in table 10.1 below. As can be seen a significant difference was found for those referred to Psychology (p<.001), with the group that did not receive any therapy waiting on average for more than two months before being contacted.

Table 10.1
Referral to First Contact in Days for Therapy and No-therapy Groups

	Therapy			No therapy					
	n	*M*	*SD*	*n*	*M*	*SD*	*t*	*df*	*p*
Nursing	108	11.44	13.05	10	29.80	57.81	1.00	9	.34
Psychology	95	28.73	30.31	17	70.59	74.67	3.98	110	**<.001**
Physiotherapy	45	9.56	15.08	7	16.43	13.24	1.14	50	.26
Occupational Therapy	28	29.21	30.54	12	28.67	45.72	0.05	38	.97
Social Work	25	64.56	62.54	4	62.00	27.31	0.08	27	.94
Speech Pathology	8	14.13	34.82	4	2.75	3.20			
Dietetics	3	15.67	19.14	1	41.00				

A series of *t*-test and chi-square analyses were performed, comparing the group that received no therapy at all (n = 25), with the remainder of the sample (n = 150), on demographic (gender, age, education, estimated premorbid IQ), injury-related (cause of injury, PTA, severity, hospitalisation) and post-injury (FIM scores, RPQ scores, HADS anxiety scores and HADS depression scores) variables. The two groups were also compared on location (residence in northern or southern Tasmania) to ascertain if geographical location was a factor in whether participants received therapy or not. No significant differences were found for any of these comparisons. See Appendix X for details of these analyses.

The group that received no therapy in any discipline (*n* = 25) were not included in any further analyses, and from this point forward the total sample refers to those who received some therapy, in at least one clinical discipline. This group consists of 150 participants.

Baselines for anxiety, depression, PCS and functional independence were calculated from the HADS, RPQ and FIM scores from the time-point at which participants were referred, or the closest one before their referral, as described in study 4.

Participants were divided into two or three groups for each variable as follows:

Demographic:

Gender	Female/Male
Age-at-injury	Younger (16-30 years)/Older (> 30 years)
Education	Low (≤ 11 years) / High (> 11 years)
IQ (NART/WAIS Vocab.)	Low (< 100) / High (≥ 100)

Injury-related:

Cause of injury	Assaults / Transport-related / Falls
Previous TBI	No previous TBI / Previous TBI
Injury-severity	Mild (≤ 24 hrs PTA) / Mod/Severe (> 1 day PTA)
Hospitalisation	Not hospitalised / Hospitalised

Post-injury:

Post-concussion symptoms (RPQ)	Minimal to mild / Moderate to severe
Functional independence (FIM)	Independent / Not-independent

Anxiety (HADS)	Normal to mild / Mod to severe
Depression (HADS)	Normal to mild / Mod to severe

10.2.5 Analyses.

Independent sample *t*-tests (2-tailed), and chi-square analyses were performed to explore the impact of the variables, characterised as indicated in the preceding section, on total hours of therapy (TT) for the whole sample (from any discipline) and for each of the clinical disciplines of Nursing, Psychology, Physiotherapy, Occupational Therapy and Social Work, for TT from clinicians in that discipline. When participant numbers were sufficient, one way analyses of variance (ANOVA) were performed for continuous variables split into smaller categories. Due to the small numbers in the samples referred to Speech Pathology and Dietetics, none of these analyses were performed for these disciplines.

Data were analysed using the Statistical Package for the Social Sciences (SPSS).

10.3 Results

The results of this study are presented in four sections: the first section looks at time-in-days from referral to first contact and referral to first appointment for the whole sample (n = 150) and for the groups referred to individual disciplines; the second section gives details of the modality of therapy participants received in each of CRU's seven disciplines; the third section compares the groups that received a home visit, on total hours of therapy, with the groups that did not receive them in the whole sample and individual disciplines; the fourth section section looks at the impact of the study variables described above, on total hours of therapy (TT) across disciplines and for separate disciplines.

10.3.1 Wait-times in separate disciplines.

The analysis presented in table 10.1 above, indicated that CRU's disciplines have varying wait-times from referral to first contact. As this may have impacted on participants' engagement with the discipline, it was decided to look at this in more detail. Time-in-days, from referral to first contact, and referral to first appointment, were calculated, for all participants referred to CRU's seven clinical disciplines. The results are shown in table 10.2, and displayed graphically in figure 10.1.

Table 10.2

Referral to First Contact and First Appointment in Days for Separate Disciplines

(*n* = 150)	*M*	*SD*	Median	Range	% of referrals contacted
Nursing					
First Contact (*n* = 118)	13.00	20.96	7.00	0 - 188	89%
Appointment (*n* = 79)	19.23	20.76	12.00	0 – 91	
Psychology					
First Contact (*n* = 112)	35.08	42.54	20.00	0 - 239	94%
Appointment (*n* = 103)	50.69	40.94	41.00	3 - 198	
Physiotherapy					
First contact (*n* = 52)	10.48	14.92	4.00	0-64	91%
Appointment (*n* = 51)	44.47	53.98	28.00	1 - 294	
Occupational Therapy					
First contact (*n* = 40)	29.05	35.15	13.00	1-147	80%
Appointment (*n* = 33)	78.94	66.62	62.00	1 - 280	
Social Work					
First contact (*n* = 29)	64.21	58.59	64.21	0-232	67%
Appointment (*n* = 26)	69.38	63.32	69.38	0 - 235	
Speech Pathology					
First contact (*n* = 11)	19.82	28.59	7.00	0-100	92%
Appointment (*n* = 8)	97.88	114.07	31.00	4 - 275	
Dietetics					
First contact (*n* = 4)	22.00	20.12	23.50	0 - 41	100%
Appointment (*n* = 4)	75.50	83.10	45.00	17 - 195	

It should be noted that these analyses included wait-times for those who failed to attend appointments, as well as those who attended them, and therefore the samples involved are larger than the samples who received therapy in each discipline.

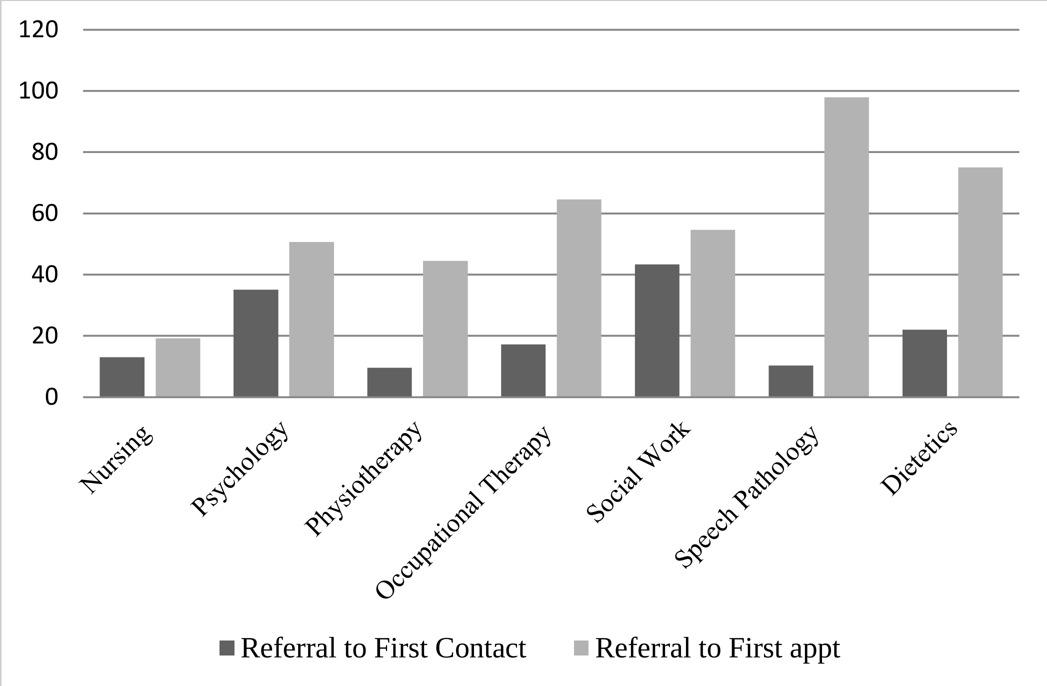


Figure 10.1 Time-in-days from Referral to First Contact and First Appointment for Separate Disciplines

10.3.2 Modality of therapy.

Table 10.3 gives details of the modality of therapy (face-to-face, telephone or a combination of the two) that participants received in CRU's seven disciplines. As can be seen from this table, a proportion of those referred to each discipline received no therapy in that discipline, some after being offered an appointment and some without being offered one. In some disciplines the number of those referred falling into this category was a significant percentage of the total number referred to that discipline: for example 40% of those referred to Social Work and 42% of those referred to Occupational Therapy received no therapy at all, in those disciplines.

Table 10.3

Details of Modality of Therapy in Separate CRU Disciplines

	Face-to-face and telephone	Face-to-face only	Telephone only	No-therapy [a]	Total receiving therapy
Nursing (*n* = 132)	37 (28%)	36 (27%)	35 (27%)	24 (18%)	108
Psychology (*n* = 119)	27 (23%)	58 (49%)	10 (8%)	24 (20%)	95
Physiotherapy (*n* = 57	12 (21%)	30 (53%)	3 (5%)	12 (21%)	45
Occupational Therapy (*n* = 50)	11 (22%)	14 (28%)	4 (8%)	21 (42%)	29
Social Work (*n* = 43)	13 (30%)	5 (12%)	8 (19%)	17 (40%)	26
Speech Pathology (*n* = 12)	2 (17%)	4 (33%)	2 (17%)	4 (33%)	8
Dietetics (*n* = 4)	1 (25%)	2 (50%)		1 (25%)	3

Note. [a] "No-therapy" refers to receiving no therapy in that discipline, not to receiving no therapy in any discipline

Some of those referred to each discipline, with the exception of Dietetics, received therapy by telephone (TTC) only. While this constituted only a small proportion of the participants referred to in some disciplines, the proportion who received only TTC was much higher in others: for example 19% of Social Work referrals and 27% of Nursing referrals received only TTC. In these two disciplines TTC also formed a significant proportion of the total therapy received: one third (32%) of therapy hours in Social Work, and one quarter (26%) in Nursing, was by telephone. In the other five disciplines TTC constituted a much small percentage of total therapy time. However, in view of the significant role that telephone therapy played in some disciplines, and the fact that some participants in all disciplines, except Dietetics, did receive some therapy by telephone, the measure of therapy used in this study was total therapy (TT), that is the total sum of face-to-face and telephone therapy, in hours.

Participants received, across all disciplines, an average of 7.18 (*SD* = 11.00) hours TT, with a range from 10 minutes (one therapy phone call) to 82.5 hours and a median of 3.25 hours, with the majority (64%) receiving five hours or less. Only 13% received at least 15 hours therapy. Details of the mean, standard deviation, median and range of therapy hours for each discipline can be found in table 10.4.

Table 10.4
Amount of TT in Whole Sample and Separate CRU Disciplines

	M	*SD*	Mdn	Range	Percentage by telephone
Whole sample (n = 150)	7.18	0.73	3.25	0.17—82.50	7%
Nursing (n = 108)	1.05	0.73	1.00	0.17—3.83	29%
Psychology (n = 95)	5.21	6.27	3.00	0.17—32.00	4%
Physiotherapy (n = 45)	6.74	11.81	2.00	0.17—73.33	1%
Occupational Therapy (n = 29)	2.52	2.19	1.50	0.17—9.67	7%
Social Work (n = 26)	2.36	2.98	1.33	0.17—12.00	32%
Speech Pathology (n = 8)	1.90	2.67	1.00	0.17—8.00	8%
Dietetics (n = 3)	2.11	1.92	1.00	1—4.33	11%

10.3.3 Home visits (HVs).

Clinicians in four disciplines, Nursing, Psychology, Social Work and Occupational Therapy, visited participants in their home for therapeutic purposes. One third of those referred to Nursing received a HV and this was often the first point of face-to-face contact, in order for a nurse to perform an initial interview. HVs in other disciplines were fewer in number and usually took place during the course of therapy for a specific reason, such as to assess an individual's need for assistance from other services, or to arrange for home modification such as hand rails to be installed. In order to answer the question raised in study 2, as to whether contact by HV resulted in greater engagement with the service, the samples receiving HVs were compared, on total hours of therapy, with the samples that did not receive them, for the whole sample and for individual disciplines. The results can be seen in table 10.5. In all the comparisons the samples receiving HVs had more mean hours of therapy. This difference was significant for Nursing (p<.001) and verging on significance for Psychology (p=.012).

Table 10.5
Effect of HVs on TT in Whole Sample and Separate Disciplines

		n	*M*	*SD*	*t*	*df*	*p*
Whole Sample	Home visit	40	11.00	10.91	2.62	148	.01
	No home visit	110	5.78	10.74			
Nursing	Home visit	32	1.55	0.68	5.08	106	**<.001**
	No home visit	76	0.84	0.65			
Psychology	Home visit	4	12.83	5.64	2.55	93	.012
	No home visit	91	4.88	6.11			
Occupational Therapy	Home visit	3	4.06	0.96			
	No home visit	26	2.34	2.23	1.30	27	.21
Social work	Home visit	5	3.43	3.89	0.91	24	.37
	No home visit	21	2.08	2.79			

Note. Two individuals received HVs in both Nursing and Social Work
One individual received HVs in Nursing, Social Work and Occupational Therapy

10.3.4 Impact of study variables on total therapy in hours (TT).

One way Analyses of Variance (ANOVA), independent sample *t*-tests and chi-square analyses were performed to explore the impact of a range of demographic, injury-related and post-injury variables on total hours of therapy (TT) for the whole sample across disciplines, and for each of the clinical disciplines of Nursing, Psychology, Physiotherapy, Occupational Therapy and Social Work, for TT from clinicians in that discipline. Due to the small numbers in the samples referred to Speech Pathology and Dietetics, these analyses were not performed for these disciplines.

Results of these analyses which were statistically significant (p<.01) or approaching significance ($p \leq .01$ but <.05) are displayed in tables 10.6, 10.7 and 10.8 below. Further details of the analyses are given in Appendices Y and Z.

10.3.4.1 Whole sample.

Significant differences in the total number of hours of therapy across disciplines, were found for one variable: age-at-injury (see table 10.6). Post-hoc comparisons using the Tukey HSD test indicated that the mean hours of therapy for those 16 to 30 years of age was significantly less (p = .003) than those aged 41 to 59. No other significant differences were found between the age groups.

10.3.4.2 Nursing.

Significant differences in TT from clinicians in the discipline of Nursing were found in the groups differentiated by the depression scale of the HADS (p = .001). Differences approaching significance were found for functional independence measured on the FIM (p = .042), and previous TBI (p = .045). As can be seen in table 10.7, those reporting moderate to severe depression, those with some level of functional dependence and the sample that had experienced a previous TBI received more therapy.

10.3.4.3 Psychology.

As shown in table 10.8 significant differences, in TT in Psychology, were found for scores on the RPQ (p = .002) and the FIM (p = .005) and there was a difference that was very close to statistical significance on the depression scale of the HADS (p = .011): the sample reporting moderate to severe levels of PCS on the RPQ, received on average, twice as much therapy as those with minimal to mild symptoms. Those who were not functionally independent on the FIM received almost twice as much therapy as the independent group, while the sample reporting moderate to severe levels of symptoms of depression were given, on average, two and a half times the therapy received by those reporting normal to mild depressive symptoms.

10.3.4.4 Other disciplines.

No significant differences were found, for any of the variables in this study, in the amount of therapy received in the disciplines of Physiotherapy, Occupational Therapy and Social Work. These analyses were not performed for the disciplines of Speech Pathology and Dietetics because of the small size of the samples referred to those disciplines.

Table 10.6:
Significant Relationships Between Study Variables and TT Across Disciplines

Age-at-injury (*n*)	*M*	*SD*	F = 4.59	**p =.006**	Post-hoc Comparisons
16-30 years (48)	3.74	4.20			v 3; p =.003
31-40 years (45)	6.45	13.85			n.s.
41-59 years (41)	11.80	16.82			v 1; p =.003
>59 years (16)	7.66	7.22			n.s.

Table 10.7:
Significant Relationships Between Study Variables and TT in Nursing

	n	*M*	*SD*	*t*	*df*	*p*
Previous TBI				2.02	106	.045
No previous TBI	84	0.97	0.74			
Previous TBI	24	1.31	0.64			
Depression (HADS)				3.30	92	**.001**
Normal to mild	63	0.90	0.52			
Moderate to severe	31	1.41	0.73			
Functional Independence (FIM)				2.06	102	.042
Not-independent	66	1.16	0.79			
Independent	37	0.85	0.60			

Note. Includes relationships that were approaching significance (*p* <.05)

Table 10.8:
Significant Relationships between Study Variables and TT in Psychology

	n	*M*	*SD*	*t*	*df*	*p*
Post-concussion symptoms (RPQ)				3.72	70	**.002**
Minimal/mild	32	3.16	1.60			
Moderate to severe	61	6.43	7.48			
Depression (HADS)				2.74	26	.011
Normal to mild	61	3.77	2.86			
Moderate to severe	25	9.48	10.27			
Functional Independence (FIM)				2.91	81	**.005**
Not-independent	63	6.19	7.37			
Independent	30	3.25	2.17			

Note. Includes relationships that were approaching significance (*p* <.05)

In summary, the findings in this study were:

- Twenty five participants, 14 % of the total sample, received no therapy at all from any discipline. No significant differences were found between this group and the remainder of the sample on a range of variables, and subsequent analyses were performed on the remaining 150 individuals who received some therapy at CRU.

- Participants received an average of 7.18 hours of therapy during their rehabilitation at CRU
- Some individuals in every discipline received therapy only by telephone, and in some disciplines, Social Work (19%) and Nursing (27%) a significant proportion of those referred received only telephone therapy (TTC).
- A third of therapy time in Social Work and more than a quarter in Nursing was TTC, while in other disciplines TTC varied from 1% in Physiotherapy to 11% in Dietetics.
- The amount of total therapy (TT) participants received in separate clinical disciplines varied from a mean of 1.05 hours in Nursing to a mean of 6.74 hours in Physiotherapy.
- The time from referral to a discipline and first contact by that discipline varied from a mean of 13 days in Nursing to a mean of 64 days in Social Work.
- The time from referral to a discipline and offer of an appointment varied from a mean of 19 days in Nursing to a mean of over three months in Speech Pathology.
- The time between referral and first contact in Psychology was significantly shorter (p <.001) for those who received some therapy in that discipline, compared with those who were referred, but received no therapy.
- HVs were associated with increased hours of therapy in the whole sample and in all of the disciplines which practiced them. This difference was significant (p <.001) in Nursing, and verging on significance in Psychology (p = .012).

- Younger age was associated with fewer hours of TT compared to older age, with this difference reaching significance for the group aged16 to 30 years, compared with those aged 41 to 59 years (p = .003).
- Those reporting moderate to severe levels of depressive symptoms received more therapy in Nursing (p = .001), and Psychology (p = .011) than those with fewer symptoms.
- Those with some level of dependence on the FIM received more therapy in Psychology (p = .005), than those who were fully independent.
- Those reporting moderate to severe levels of PCS received more therapy in Psychology (p = .002) than those with fewer symptoms.
- Nursing tended to give more therapy to those who were not functionally independent on the FIM (p = .042) and those with a history of previous TBI (p = .45) compared to those who were functionally independent and those with no history of TBI, although these differences did not reach significance.
- No significant differences were found for any of the study variables in Physiotherapy, Occupational Therapy and Social Work

10.4 Discussion

Participants received an average of 7.18 hours of therapy during their rehabilitation at CRU. This is quite a modest amount of input, and highlights the importance of seeking out those most likely to derive benefit from referral to CRU. The amount of therapy provided varied across disciplines: from a mean of 1.05 hours in Nursing to a mean of 6.74 hours in Physiotherapy, While some disciplines—notably Social Work and Nursing—gave only therapy by telephone (TTC) to a portion of those referred, in other disciplines therapy was almost always provided face-to-face. This reflects the nature of the clinical services provided by different disciplines: For example an important role for social workers at CRU was assisting patients to access resources, which could frequently be achieved through telephone contact, whereas Physiotherapy programs were based on functional goals to assist physical recovery and required face-to-face contact. Twenty five participants, (14%) of those referred to CRU did not receive any therapy at all. Two of these participants were not referred to any clinical discipline. During the period of this study, all referrals to CRU were triaged at an intake meeting. If they were inappropriate for any reason, they were returned to the referrer; otherwise they were referred to one or more of CRU's clinical disciplines. This suggests that the two participants not referred to a discipline may have been overlooked and not gone through this process. The remaining participants in the no-therapy group were referred to at least one discipline, and ten were given an appointment, which they either cancelled or failed to attend. No significant differences were found between the group that did not receive any therapy and the larger sample on any of the variables in this study.

The relationship between the number of clinical disciplines participants were referred to and a range of demographic, injury-related and post-injury variables was examined in previous studies reported in this thesis. The only significant association found was with increased injury-severity (p=.006), although a history of previous TBI (p=.041) and older age (p=.049) were approaching significance. It was hypothesised that in the present study these factors would be associated with intensity of service, as measured by the number of hours of therapy participants received. The results obtained indicated that increased injury-severity and previous TBI were not associated with increased therapy across disciplines, although both of these factors were associated with increased therapy in specific disciplines.

The variable associated with increased therapy across disciplines was age-at-injury. Those in the youngest age bracket, that is those up to 30 years of age, had on average less than four hours of therapy during their rehabilitation at CRU, compared with an average of 6.45 hours for the 31 to 40 year old group and 7.66 hours for those sixty years and over. However it was those in the 41 to 59 age bracket and not those over 60 years of age who received the largest amount of therapy: on average they received almost 12 hours of therapy.

Numerous studies have indicated that increasing age is associated with poorer psychosocial, cognitive and functional outcomes (Goleburn & Golden, 2001) and a greater need for assistance (Whiteneck, et al., 2004a) compared with younger TBI patients, with the greatest disability consistently shown in older adults, typically those over 60 (Rothweiler, et al., 1998; Susman, et al., 2002; Whiteneck, et al., 2004a). It is therefore surprising that it was the middle aged participants in the present study who received the most overall therapy and not those in the oldest age bracket. One possible reason for this may be that this age group are likely to have different goals for rehabilitation—such as return to work—compared with an older population who are more likely to be retired (Turner-Stokes, et al., 2005) and may feel less pressure to try and return to premorbid functioning. Analysis of employment status by the four age categories (Appendix AA) indicated that only 31% of the over-59 years-of-age group were in payed employment compared with 49% of the 41-to-59-years-of-age category. However this difference was not statistically significant, possibly due to the small number (n = 16) of individuals in the sample aged over 59 years. Another factor may be that difficulties may be more apparent when someone who has sustained a TBI returns to work, whereas those who are retired may be less aware of impairments arising from their injury.

In this context, it is also difficult to separate factors associated with a need for therapy and factors associated with engagement with the clinical services offered at CRU. The smaller amount of therapy that those 60 years and over received, compared with the group aged 41 to 59 years of age, may relate to factors such as an inability or disinclination to travel for appointments, which could also partially account for the relatively small numbers of participants in this age group. It may be that older TBI patients were referred for services in their local community, because of inability to travel, even though some of the services available at CRU would not be available locally. For the youngest group on the other hand, which constituted almost one third of the sample, lack of engagement with the service may have been due to lack of need, but alternatively it may have resulted from a perception that rehabilitation services were not relevant to their difficulties, or a lack of motivation to take part in the rehabilitation process. This would be consistent with the findings from a concussion clinic in New Zealand for mTBI patients (Snell & Surgenor, 2006) which found that younger patients were more likely to fail to attend appointments than older ones. A meta-analysis of studies reporting adherence to medical treatments which looked at 164 studies of correlations between adherence and patients' age, gender, education and income/social status found that, although on the whole, demographic effects on adherence are small, greater adherence is associated with older age, female gender, higher income and more education (DiMatteo, 2004). Interestingly results of the present study also indicate that females received 50% more therapy, compared to males (mean of 9.37 hours *SD*:15.14 for females, mean of 6.04 hours *SD*:7.95 for males), although this difference was not statistically significant, possibly because of the high variance in the sample, as indicated by the large standard deviation.

The small amount of extant research looking at premorbid intellectual ability in TBI samples indicates that individuals with lower IQ are likely to be at risk for poorer outcomes, and therefore more in need of assistance from rehabilitation services, than those with higher levels of intelligence. Although IQ was not significantly related to hours of therapy in this study, the results did indicate a trend in the direction of an association between increased hours of therapy and higher IQ: the group with IQ less than 90 received on average 5.25 hours, compared with 16.83 hours for those with an IQ over 109. This result is consistent with previous research which has shown higher intelligence to be associated with continuing engagement with health self-care, even in the face of uncertainty about whether the treatment is known to be effective in general, and whether it will be helpful to the individual participating in it (Deary et al., 2009).

As outlined in chapter 2, indicators of severity, such as length of loss of consciousness (LOC), measurement of depth of coma using the Glasgow Coma Scale (GCS) and duration of post-traumatic amnesia (PTA), have been found to be predictive of psychosocial, cognitive and functional outcomes following TBI (Dikmen, et al., 1995a; Gordon, et al., 2006; Ownsworth & McKenna, 2004). For example a prospective study by Dikemen et al. (1995a), found that 436 adult head-injured participants performed significantly worse on a range of neuropsychological measures compared to control group participants (n = 121) that had experienced trauma without neurological injury, and the magnitude and pervasiveness of impairments was dependent on injury-severity in a dose-response relationship. It might be expected therefore that those with increased injury-severity would have more need for rehabilitation and therefore more hours of therapy overall. While the results of previous studies indicate that those with more severe injuries were referred to more disciplines, the results of the present study found that, overall, the amount of therapy they received was not significantly more than those with milder injuries. This result is surprising, because although research has found that disability is as common after mild injuries as it is after more severe ones (Thornhill, et al., 2000; Whitnall, et al., 2006), the magnitude of impairments following more severe injuries is much greater (Ponsford, 1995).

There are a number of possible explanations why the amount of therapy was not related to injury-severity in this study. One is that those with milder injuries may have been experiencing more PCS than those with more severe injuries. Persistent PCS, are more common following mild to moderate injuries than following severe TBI (Mittenberg & Strauman, 2000), and are associated with increased anxiety, significant depression and post-traumatic stress (King, 1996), all of which might be expected to be targets for therapy. It may be that a significant proportion of those with milder injuries in this study presented to rehabilitation services at CRU with these symptoms and consequently an increased need for assistance, and they therefore received more hours of therapy. In more severe injuries, on the other hand, lack of insight has been shown to result in a lack of awareness of deficits which, although it may prevent the development of psychiatric symptoms, can also be a barrier to the engagement with rehabilitation services. Guidelines for TBI rehabilitation, for example those developed in New Zealand (New Zealand Guidelines Group, 2006), point to the need for services to take account of executive deficits, which may manifest themselves in unawareness of difficulties, and in some cases active denial of the effects of the injury. Memory problems are another very common consequence of TBI which can affect engagement with rehabilitation services: appointments may be missed simply because patients forget to attend them. It may therefore be that those with injuries at the severe end of the spectrum did have more need for services at CRU, and consequently were referred to more disciplines, but their engagement with the service was limited due to factors such as lack of insight and difficulties with memory. To overcome these difficulties, current guidelines for TBI recommend an antecedent approach to therapy, in which proactive strategies are used to identify potential challenges and barriers for individuals in advance, rather than a more traditional approach to behavioural management which relies on consequences and rewards applied after the event (Ylvisaker, Jacobs, & Feeney, 2003). However, many CRU clinicians may have been unaware of these kinds of approaches with TBI patients. It is also possible that, because CRU was not a specialist TBI rehabilitation unit with the clinicians and resources to provide holistic cognitive rehabilitation programs for TBI patients (as described in chapter 4), the services provided were not commensurate with the difficulties that more severely injured participants presented with.

The results of Studies 2, 3 and 4 indicated that some variables were related to referral to particular disciplines: for example referrals to Physiotherapy and Occupational Therapy were more likely to be participants who were older, those who had been hospitalised, those with more severe injuries. Surprisingly the variables of age and hospitalisation were not associated with increased use of services in the current study and in Occupational Therapy there was a trend towards participants who had not been hospitalised receiving more therapy than those who had been hospitalised, although this was not significant. It may be that other things, such the ability of older participants to attend appointments or long waiting times for appointments due to staff shortages, were important factors in how much therapy participants received in these disciplines.

The findings from study 3 indicated that Nursing tended to offer more appointments to those with a previous history of TBI compared with those who had not previously experienced one. As this may reflect a higher priority given to those with a previous TBI by the clinicians in Nursing, it was hypothesised in the present study that these individuals would be offered more hours of therapy. Results of the present study do in fact indicate that this was the case. A history of TBI was associated with longer therapy times in Nursing, although this only approached significance (p = .045). Hospitalisation, however, was associated with an increased likelihood of referral to Physiotherapy and Occupational Therapy in study 3, and one of the questions arising from that study was whether or not hospitalisation would be associated with increased therapy in those disciplines. Surprisingly, hospitalisation was not associated with increased therapy in these disciplines, or any other disciplines in the present study.

Study 4 found that those who were not fully independent on the FIM were more likely to be referred to Occupational Therapy but no association between total therapy (TT) in Occupational Therapy and functional dependence was found in the present study. However it is interesting to note that the present study did find a strong association between dependence on the FIM and increased hours of therapy in Psychology and also a trend towards more therapy in Nursing. This may be because the FIM measures dependence in cognitive (5 items), as well as physical functioning (Linacre, et al., 1994). Disability in cognitive functioning might best be addressed by Nursing for information and education followed by referral to Psychology and this may account for the association between increased therapy in those disciplines and lower FIM scores.

The FIM has been found to have ceiling effects (Hall, et al., 1996) and may not have been the most appropriate measure of functional independence, particularly in the area of physical functioning, for the present sample which included many mild injuries. The motor items in the FIM are ones on which the majority of those with mild to moderate TBI would be expected to be completely independent, and even those with more severe injuries referred to Physiotherapy for movement disorders may have been independent on items such as stair climbing and locomotion. More information on this could be obtained by looking at the individual item scores on the FIM, and the two-subscales (motor functions and cognitive functions) which Linacre et al. (1994) have identified using Rasch analysis. This was beyond the scope of the present study, because individual scores were not available for analysis.

The average amount of therapy participants received varied considerably between disciplines, probably reflecting differences in the services offered. The lowest mean hours of therapy was in Nursing where participants received, on average just an hour of therapy, compared with almost seven hours in Physiotherapy and five hours in Psychology. No participant received more than three face-to-face sessions in Nursing. Nevertheless, despite the brevity of therapy, Nursing performed an important role for TBI patients at CRU. Nursing received referrals for 88% of the sample in the present study and 87% of the larger sample in studies 2, 3 and 4. Time from referral to first contact was shorter for Nursing than for any other discipline—one half of the sample was seen in the first fortnight after referral—and when the participant was unable or unwilling to travel to CRU for an appointment the initial assessment was performed on a home-visit (HV). Initial face-to-face contact was by HV for a significant portion of those referred to Nursing, while in other disciplines HVs were fewer in number and usually took place during the course of therapy for a specific reason, such as to assess an individual's need for assistance from other services or their need for an intervention in the home. Comparison of the amount of therapy received by the samples who received a HV and those that did not receive one, indicate that, although the numbers were too small in the disciplines of Psychology, Social Work and Occupational Therapy to make these comparisons meaningful, in the discipline of Nursing ($p < .001$) there was a significant differences, with those who received a HV receiving significantly more therapy.

The role of education in rehabilitation following TBI has been extensively investigated, in those with mild injuries. There is good evidence from RCTs that early intervention within the first few weeks of a mild injury does significantly reduce PCS and limit the emergence of persisting problems (Mittenberg, et al., 2001; Ponsford, et al., 2002; Wade, et al., 1998). However despite the evidence that provision of information and reassurance is effective in reducing disability in mild injures, severe enough to be admitted to hospital and/or which have a PTA of greater than one hour, routine follow-up of TBI patients in these categories was not taking place in the RHH during the current research. MTBI patients presenting to the ED and subsequently sent home, were, at best, given only a half-page information sheet with instructions about what should be done in the first 24 hours following the injury, a recommendation to call their doctor or return to the hospital in the event of experiencing any one of a number of symptoms listed on the sheet, and a suggestion that they go to their general medical practitioner for follow-up. Although this information sheet (see Appendix P) did provide important information about what to do in the event of worsening symptoms, it did not give reassurance that symptoms would improve. Such reassurance has been shown to be an important element in preventing persistent PCS (Alves, et al., 1993). Educational interventions do not have to be long: a single session of therapy given soon after a mild injury has been found to be as effective as a longer course of therapy, with improvements maintained at 12 months (Paniak, et al., 1998). A single appointment with Nursing could therefore have been an effective therapy for some individuals with mild injuries. Contact by telephone was also a significant aspect of the therapy provided by Nursing, constituting approximately one quarter of therapy time. Some education and advice may have been conveyed to participants by telephone, before they were referred to other services.

Symptoms of depression were associated with more therapy in Nursing: Those with scores in the moderate severe ranges on the HADS depression scale receiving more therapy than those with lower scores. This may reflect follow-up by Nursing of those with depressive symptoms, identified following referral to this discipline. However, as mentioned above, the amount of therapy participants received from Nursing was brief and the discipline with the main responsibility for providing therapeutic interventions for depression and other mental health conditions was Psychology.

Those referred to Psychology received an average of five hours of therapy with half of the sample receiving only three hours, suggesting an initial assessment and a brief intervention for most participants. Neuropsychological assessment was also a significant part of psychological services at CRU with almost half of the sample being assessed. This typically took place over two sessions with an additional session for feedback. Scores in the moderate to severe range on both the anxiety and depression scales of the HADS were associated with more hours of therapy in Psychology than scores in the normal to mild range. However, this difference was significant only for depressive symptoms, with those in the more severe range receiving, on average, more than twice as many hours of therapy as those with normal to mild range. The association between increased therapy and more severe symptoms of anxiety and depression is not surprising given that both are associated with poorer outcomes and have high rates of co-morbidity (Jorge, et al., 2004; Levin, et al., 2001) following TBI, in injuries of all severities.

Physiotherapy participants received an average of seven hours therapy, suggesting an initial assessment and a course of therapy, some of which may have been related to comorbid injuries not the brain injury itself—for example therapy for orthopaedic injuries. Referrals to Occupational Therapy received an average of less than three hours of therapy, with over half of the group receiving only a little over two hours, suggesting only a very brief intervention for most participants. During the period of this study a woodwork group and an art group were two of the services offered by Occupational Therapy services at CRU. None of the participants of this study attended the woodwork group but three attended the art group, one of whom attended fourteen sessions. These sessions were not included in the calculation of TT for Occupational Therapy participants.

The amounts of therapy participants received in Social Work were similar to the amounts received in Occupational Therapy. However, Social Work services at CRU operated in a different manner to the other clinical disciplines in several respects. Unlike other disciplines at CRU, Social Work services did not routinely contact participants referred to their service, on receipt of their referral. This is reflected in the fact that whereas the median time from referral to first contact was less than a month for all other disciplines, it was over two months for Social Work. It was apparent from examination of the clinical files that, in a proportion of cases, a judgement was made by clinicians in Social Work, to monitor the situation without contacting the individual concerned, usually because he or she was already being supported by other CRU disciplines. This may account for the comparatively low follow-up rate (67%) of Social Work referrals in the current sample compared with follow-up rates of 89% for Nursing, 94% for Psychology and 91% for Physiotherapy, shown in table 10.2. Another difference in the way Social Work services operated at CRU was the significant role that therapy in the form of telephone calls played: one fifth of participants had no face-to-face contact with clinicians and contact by telephone was a significant part of this discipline's contact with all participants: overall one third of therapy time was in the form of phone calls

Social Work services assist the injured individual and their family to adjust to their disability and any lifestyle changes that may result from it. Services typically include educational information and case management, as well as service co-ordination, liaison, referral, resourcing and discharge planning. For participants referred in the current research, it was apparent from the clinical files that a significant amount of time was spent liaising with services in the community and with other disciplines in CRU. Face-to-face assessments were fewer than in other disciplines and although some individuals were visited in their homes, this was often to assist with service liaison, rather than for assessment purposes.

Preceding studies indicated that those with moderate to severe levels of reported depressive symptoms on the HADS were more likely to be referred to Social Work. However these variables were not associated with an increased likelihood of being offered an appointment. The question arose: were participants with higher levels of depression who were not offered an appointment followed up in Social Work by telephone? Table 10.3 does indicate that eight individuals received only telephone therapy. However only three of these participants had not been offered an appointment in Social Work: the other five were offered an appointment which they did not attend. Furthermore the three who had not been offered an appointment were not reporting moderate or severe levels of depression symptoms. It is therefore apparent that participants who were reporting higher levels of depression, but were not offered appointments in Social Work, were not followed up by the social workers using telephone therapy. Information about why this was the case was not available for the current study.

Another factor in participants' engagement with the therapeutic services offered by CRU's different clinical disciplines may have been the amount of time they waited before being contacted by the service, and/or the amount of time they waited to receive an appointment. As can be seen from figure 10.2, this varied from discipline to discipline. As discussed above, follow-up times were short for both initial contact and appointment times in Nursing. While this reflects a focus by the discipline of Nursing on providing follow-up for TBI patients, perhaps because of the role of Nursing in the brain injury clinic and also the personal interest of one of the rehabilitation nurses, it also suggests adequate resourcing of this service for the needs of TBI patients, which was lacking in some of the other disciplines. The average time from referral to first contact was shorter for Physiotherapy than any other discipline. This was due to a policy of promptly sending a letter to anyone referred to Physiotherapy, either offering an appointment or informing the individual that their referral had been received and an appointment would be sent out in due course. This service was provided by an allied health assistant, a number of which were employed at CRU to provide both clinical and administrative support. Follow-up in Physiotherapy was usually timely, with the majority of participants offered an appointment within the first four weeks following receipt of their referral. Speech Pathology on the other hand suffered from an extended interruption of services, from March 2005, when the single speech pathologist working at CRU left the service, until November 2006 when another clinician was employed. Referral to first contact was on average only 20 days, but this was largely because a letter was sent acknowledging the referral and explaining that wait times were likely to be lengthy because of staff shortages. The mean wait time for the eight participants who were offered appointments was 97 days, but three members of this group who were referred for speech pathology services in 2006 waited on average for 229 days before attending an appointment, while mean wait times for the rest of the group was only 18 days. This lack of speech pathology services, for such an extended period, reduced referrals and may have resulted in some of those who were referred seeking speech pathology services elsewhere: For example, two of those referred in 2006 failed to attend the appointment offered to them by the new speech pathologist recruited in November of that year, suggesting they may have seen a speech pathologist in the community or the private sector in the interim.

Wait-times may have also been a factor in engagement with Occupational Therapy services at CRU because, as outlined in chapter 4 of this thesis, although it was the second only to Physiotherapy in the number of staff and staff hours available at CRU, demand for Occupational Therapy services was greater than supply for the whole period of this study. Similarly to Physiotherapy, there was a policy in place of writing to those referred to the service in a timely manner—referral to first contact times were within two weeks for the majority of those referred. However time to first appointment was on average two months, and for more than a third of those referred it was three months. Only four participants were referred to Dietetics. They were contacted in a timely manner but waiting times for appointments were very variable with a range from 17 to 195 days, due to staff shortages.

Mean times from referral to first contact were longest for Social Work and Psychology. Possible reasons for longer waiting times for Social Work are discussed above. For Psychology one reason may have been staff shortages: in 2005 there was a reduction in service for a number of months due to staff shortages. A large proportion of the sample was referred to Psychology and it may have taken some time for this discipline to adjust to the increased demand on its service resulting from referrals from the TNTR project. A comparison of wait-time-in-days from referral to first contact for the groups that received therapy and those that did not, found that there was a significant difference for Psychology ($p<.001$): those who did not receive therapy had longer wait times than those who did. This suggests that the time that participants had to wait to be contacted may have been a factor in their engagement with the service. However it may be that this result reflects difficulties contacting some TBI patients referred to Psychology, many of whom were young and unemployed and may not have had a fixed address. As outlined in chapter 5, when CRU was established in 2003 psychological services were largely confined to neuropsychological assessment provided by one staff member who worked one-day a week (0.2 FTE). In 2004 a part-time clinical psychologist was employed and in 2005 the two services, neuropsychology and clinical psychology, were joined into one. Referral of a large number of participants to CRU, many of whom required psychological services, may have been a factor in the expansion of the service, which by 2007 employed two full-time staff.

10.4.1 Limitations.

One of the limitations of this study is the retrospective collection of data from clinical files, the accuracy of which will be partially determined by the accuracy of recording by individual clinicians. Additionally, the length of time taken for therapy telephone calls, were a retrospective estimation in most cases because the length of telephone calls were not routinely recorded in the clinical notes. However these estimations were made in consultation with clinicians in each of the clinical disciplines, in order to achieve the most accurate data possible under these circumstances.

10.4.2 Summary and research directions.

In summary, this study has provided information about the amount and nature of therapy that participants received at CRU, as well as details of some of the factors, such as follow-up times between referral and first contact and first appointment, which may have influenced the therapy received. On average participants received 7.18 hours of therapy across disciplines. This is quite a modest amount of input by services at CRU and highlights the importance of seeking out those most likely to derive benefit from referral for rehabilitation. In every discipline a proportion of therapy was by telephone. While in some disciplines the proportion of telephone therapy was small, in others such as Nursing and Social Work it was a significant amount of the total therapy provided. The variable associated with increased amounts of therapy across disciplines was age-at-injury. However this association was statistically significant only for the youngest group (up to 30 years), which received the least amount of therapy, compared with the group aged 41 to 59 years, which had the longest mean time. Variables that showed a trend towards association with larger amounts of therapy across disciplines were higher IQ and female gender, providing some very limited confirmation of previous research which has found a correlation between these variables and compliance with medical treatment.

The finding from the present study that increased injury-severity was not associated with more therapy is surprising because, although disability has been shown to be as common after mild injuries as it is following more severe injuries, the magnitude of impairments following more severe injuries is much greater. However, it may be that factors such as lack of insight into their disabilities or memory problems resulting in forgetting appointments reduced severely injured participants engagement in therapy in the present study. It is also possible that, because CRU was not able to provide specialist TBI rehabilitation, the services provided were not commensurate with the difficulties that more severely injured participants presented with. In individual disciplines other factors were associated with increased amounts of therapy: notably higher levels of depression were associated with increased therapy in both Nursing and Psychology and some level of functional dependence on the FIM, and higher levels of PCS were associated with increased therapy in Psychology. Nursing also tended to give more therapy to those who were not functionally independent and those who had previously suffered a TBI.

The average amount of therapy received varied considerably across disciplines, probably reflecting differences in the services offered. The shortest mean therapy time was in Nursing, and the longest in Physiotherapy. Although therapy in Nursing was brief, this discipline provided an important educative role for TBI patients at CRU, which previous research suggests is particularly beneficial in mild injuries. Thirty percent of participants referred to Nursing received a HV, and HVs were significantly associated with higher levels of therapy in this discipline. Psychology, gave an average of five hours of therapy to participants, with a significant association between higher levels of therapy in this discipline and higher levels of depressive symptoms. In Occupational Therapy and Social Work participants received, on average, less than three hours of therapy. In Occupational Therapy one reason for this lower level of therapy may have been relatively long waiting lists due to staff shortages; in Social Work average hours of therapy may have been lower because of the nature of therapeutic contact, which often involved liaison with other services

Time from referral to first contact, and referral to first appointment varied from discipline to discipline, depending on factors such as staffing levels and the follow-up practices of different disciplines. Occupational Therapy, Psychology and Speech

Pathology, in particular were constrained by lack of staff for periods of time during the current research. The results of this study indicate that those who were referred to Psychology but did not receive any therapy had longer wait times from referral to first contact, than those who were referred and did receive therapy. This suggests that the time that participants had to wait to be contacted may have been a factor in their engagement with the service. However it may reflect difficulties contacting some TBI patients referred to Psychology, many of whom were young and unemployed and may not have had a fixed address. The longest mean times between referral and first appointment were in Occupational Therapy and Speech Pathology, but these two disciplines both had a policy of sending out a letter to all newly referred patients informing them that their referral had been received, and that there would be a waiting period before an appointment could be offered. This did not occur routinely in Psychology. However Psychology did increase its staffing levels, and the clinical services it provided, over the time-frame of this research. The shortest times for initial contact and initial appointments were in the disciplines of Nursing and Physiotherapy. This may be due to more adequate resourcing of these disciplines, compared with disciplines that had longer waiting times.

In developing a model of pathways of rehabilitation, which is one of the overall aims of the current research, this results of the current study suggest it will be important to note the following factors:

- Older age-at-injury has been shown in previous research to be a predictor of poorer outcomes. While the current research also indicates that older TBI patients require more rehabilitation, it suggests that the age group 41 to 59 may need more therapeutic contact, than those in the older age bracket (> 60 years).

- The current study provides some confirmation of previous research which indicates that males and those with lower IQ may be more difficult to engage with therapeutic services
- Injury-severity by itself is not a good criterion for judging the need for rehabilitation services
- Follow-up in the community, by for example home-visits, may result in greater engagement with therapeutic services, particularly in a clinical population which has executive functioning and memory deficits, which may result in patients forgetting appointments
- Administrative support which ensures that patients are promptly contacted with information about when an appointment is likely to be offered, may increase their engagement with clinical services, even with longer than optimal waiting times.

CHAPTER 11 - Discussion

An increasing body of high-quality evidence now exists for the effectiveness of rehabilitation interventions for TBI of all severities. In moderate and severe injuries, research has highlighted positive effects on recovery after TBI of early intervention (Cope & Hall, 1982), cognitive rehabilitation (Carney, et al., 1999; Cicerone, et al., 2000) more intense in-patient programmes (Turner-Stokes, et al., 2005), supported-employment (Haffey & Abrams, 1991), and continued outpatient therapy in early post-acute rehabilitation (Ben-Yishay, et al., 1987; Turner-Stokes, et al., 2005). The cost effectiveness of rehabilitation for TBI has also been demonstrated (Khan, et al., 2002; Murphy, et al., 2006; Wood, et al., 1999).

In mTBI a number of studies have indicated that early educational information can reduce long-term complaints and that this early intervention need not be intensive (Mittenberg, et al., 2001; Paniak, et al., 1998; Paniak, et al., 2000; Wade, 1997; Wade, et al., 1997b). Reassurance has also been shown to be an important element in interventions for those with mild injuries (Alves, et al., 1993).

Nevertheless a number of gaps in knowledge remain. These include the following two points:

- There are very few studies of rehabilitation with TBI patients who were not hospitalised following their injury. One reason for this may be that most studies of TBI rehabilitation are associated with specialist units, which tend to look only at hospitalised cases and concentrate on rehabilitation of those with injuries at the severe end of the injury spectrum. As it has been estimated that only 16% to 25% of TBI cases are hospitalised (Fife, 1987; Sosin, et al., 1996), this means that there is limited information about the large majority of TBI cases.

- There is limited information about TBI rehabilitation services in areas without a specialist TBI rehabilitation facility. As there is wide discrepancy in the availability of specialist TBI rehab programs across geographic regions (National Institutes of Health, 1999), this means that there is no information about what happens to TBI patients in many areas. In countries such as Australia, where there are no national guidelines for TBI rehabilitation, it is particularly important to evaluate current practices, because follow-up for this population will depend not only on the availability of services, but also on the knowledge that available health professionals have about what constitutes effective rehabilitation following TBI.

Over the last twenty years a major shift in health care has occurred towards increased accountability, with a push towards increased efficiency, reduced costs and shorter inpatient-rehabilitation periods. This trend is likely to continue, particularly in Australia, New Zealand, Europe and USA where an aging population and an increase in chronic diseases over the last two decades is putting a strain on primary health care resources (Wade & De Jong, 2000). One result has been an increased interest in post-acute community rehabilitation interventions, and a number of studies have shown that they can be effective for TBI of all severities (King, et al., 1997; Powell, et al., 2002; Snell & Surgenor, 2006; Wade, et al., 1998). Significantly, they have the potential to provide early intervention after mTBI and ensure follow-up for non-hospitalised cases.

However, research suggests that only a small proportion of people, who could benefit, gain access to post-acute rehabilitation interventions (Dombovy & Olek, 1997; Mellick, et al., 2003; Wade, et al., 1998). For example, two thirds of those suffering a TBI in a population-based sample in USA received no additional services, following discharge from an acute care hospital. One possible reason for this finding may be that rehabilitation in USA is dependent on insurance status. However in UK, where follow-up is not dependent on insurance, a study of a large representative cohort of adults admitted to hospital following a TBI (*N* = 2692, of which 549 were followed up) found that only 28% reported having received input from rehabilitation services, one-year post-injury (Thornhill, et al., 2000). Survivors of this group were subsequently followed up five to seven years post-injury. Although the researchers found clear evidence of associations between adverse self-ratings of emotional well-being and moderate or severe disability, which potentially may be open to remediation, so few of the participants studied reported having received rehabilitation that they concluded that there could be no meaningful analysis of the possible effects of this intervention (Whitnall, et al., 2006).

In Australia, some studies suggest that the availability of services is influenced by location and funding (O'Callaghan, et al., 2009). However while research in some areas indicates that many TBI patients do not receive adequate outpatient rehabilitation services (Foster, et al., 2004), in other areas no information is available to confirm this. A qualitative study of service needs of individuals with ABI and their families (Turner, et al., 2011) highlights the difficulties participants experienced in negotiating the rehabilitation process between hospital and home. The findings suggest that the scope of existing service models need to be extended to bridge the gap between inpatient and community services, thereby easing the impact of transition.

With these points in mind, the aim of the present research was

- to investigate patterns of referral to post-acute rehabilitation services in a population-based TBI sample;

- to look at a range of demographic, injury-related and post-injury factors in those referred to public post-acute community rehabilitation, and investigate how they were related to their progress in rehabilitation, and
- to increase understanding of TBI and its management, by developing a model of rehabilitation pathways.

11.1 Strengths of the Current Research

The current research project has a number of strengths:

- It used a large, population-based adult sample (N = 1226), with demographic characteristics similar to epidemiological studies in Australia (for example Hillier, et al., 1997; Tate, et al., 1998) and overseas (Tagliaferri, et al., 2006).
- The large proportion (52%) of non-hospitalised cases in this sample, make it more representative of adult TBI than most studies which use only hospitalised cases.
- Data were collected prospectively on a wide-range of domains (including demographic, injury-related, functional, cognitive and psycho-social). While it is acknowledged that participation was voluntary, this procedure provided the closest approximation to population-based sampling that could be achieved together with systematic collection of injury and outcome data at multiple time-points.
- The research project was located in Tasmania, an island state of Australia with a population of 500,000, with one tertiary referral centre, the RHH (RHH) and one State-wide health-care system: very few TBI cases access care outside of the state.

- Collaboration with the multidisciplinary rehabilitation team at CRU, the single point of referral for public outpatient multidisciplinary rehabilitation in Tasmania, enabled this research to describe the rehabilitation process in all TNTR participants referred for public post-acute rehabilitation over a three-year period

11.2 Summary of Main Findings

The current research comprises five studies. Study 1 examined some demographic, injury-related and post-injury characteristics of the participants of the TNTR research project, to assess which variables predicted referral for rehabilitation and whether these variables differed according to the type of service accessed (private or public), and for the group referred for public rehabilitation, whether they differed according to referral source. It was hypothesised that those at risk of poorer outcomes would be more likely to be referred for rehabilitation. Based on literature reviewed in chapter 3 of this thesis, those who were considered at risk of poorer outcomes were participants who were older, female, had been hospitalised post-injury, had lower levels of education and/or premorbid IQ, a history of TBI, more severe injuries, functional dependence, and higher levels of physical and cognitive disability, PCS, pain, fatigue, anxiety and depression. Additionally, because a proportion of motor vehicle accidents would be compensable, it was hypothesised that the sample referred for rehabilitation in the private sector would contain a larger proportion of transport-related injuries than those referred to public rehabilitation; and because referrals by TNTR research assistants were made on the basis of a perceived gap in service provision, this group would have higher levels of PCS, pain, fatigue, anxiety and depression, than the other groups.

The results of this first study indicated that, despite containing a large proportion of non-hospitalised cases, the whole TNTR sample (N = 1226) had a higher proportion of moderate and severe cases than samples in recent Australian epidemiological studies. It also had more assault-related injuries than most epidemiological studies. One third of the whole sample was referred for rehabilitation, with the majority accessing this in the private sector as a result of transport-related injuries, the medical costs of which were funded by third-party or private insurance. On the measures of cognitive functioning, there were few significant differences between the groups referred for rehabilitation and those not accessing it, but the whole sample showed impairment on some of them, particularly two tests of executive functioning. Mean scores on a measure of working memory (Digit Span), on the other hand, were in the average range.

Three referral pathways are presented in a flow chart in figure 11.1. The variables associated with referral to CRU for public rehabilitation by the TNTR research assistants (Pathway 1: TNTR Referral) on the basis of perceived need, were mild TBI, lower education, assault-related injury, unemployment, functional independence, higher levels of PCS, anxiety, depression, pain and fatigue, and previous TBI. There was also a trend for this group to be younger than those referred by other sources. The variables that were associated with referral to CRU for public rehabilitation by hospital and community sources (Pathway 2: Other Sources) were older age (> 30 years), hospitalisation, fall-related TBI, increased severity, functional dependence and disability. There was also a trend towards those with lower education and those with a history of TBI being referred. The variables associated with referral in the private sector (Pathway 3) were older age, transport-related injuries, hospitalisation, mild TBI, functional dependence and disability.

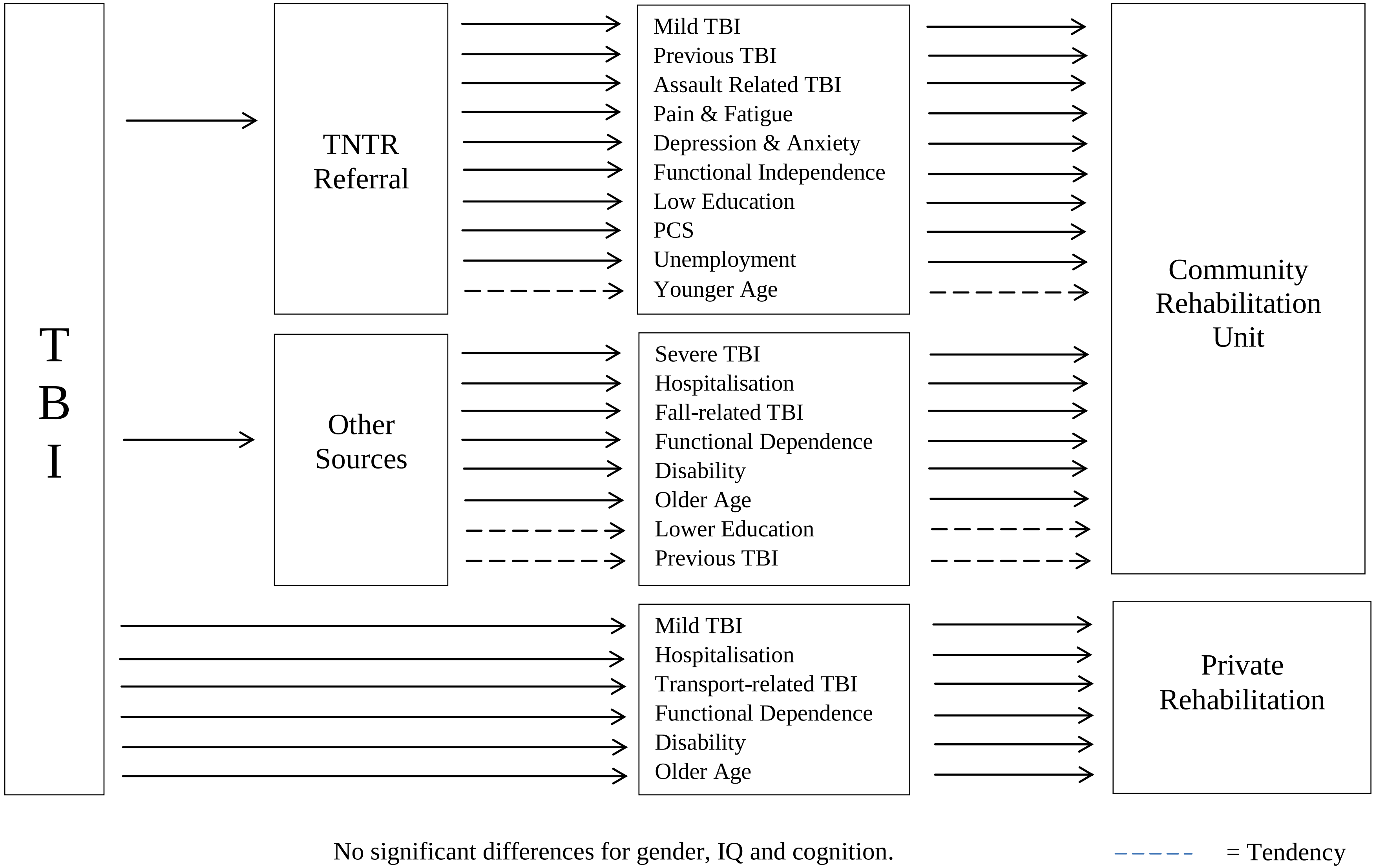


Figure 11.1. Referral Pathways

Subsequent studies in this thesis looked at the sub-sample of individuals on the TNTR who were referred for public post-acute rehabilitation to the Community Rehabilitation Unit (CRU). Study 2 looked at the demographic variables of gender, age, education and estimated premorbid IQ, and considered how they related to initial contact with CRU's clinical disciplines. It was hypothesised that increased service utilisation, as measured by the number of disciplines participants were referred to, would be associated with older age, lower levels of education and lower premorbid IQ. These hypotheses were not supported, although there was a trend towards those over 30 years of age being referred to more disciplines, than younger participants. Women have been shown to have poorer outcomes following TBI and it was therefore hypothesised that they would be more likely to access the disciplines of Nursing for assistance with PCS and Psychology for assistance with anxiety symptoms and mood disturbance. Although this was not found to be the case, Nursing did tend to offer more appointments to women. The other hypotheses in this study were that participants with lower levels of education and those with lower premorbid IQ would be more likely to be referred to Nursing and Social Work for assistance, than those with higher levels of education and IQ. While there was a non-significant trend towards participants with lower education being referred for Social Work, the other hypotheses were not sustained. The disciplines of Physiotherapy and Occupational Therapy were more likely to receive referrals for older participants, possibly for assistance with other-system injuries. There was also a significant association between referral to Physiotherapy and higher premorbid IQ, which may be due to an association of higher premorbid IQ scores, as estimated by the NART, with older age, as post hoc analyses did find a significant association between higher NART scores and increasing age.

Study 2 also provided information about the proportions of the sample referred to separate CRU clinical disciplines and found that larger proportions of the sample were referred to the disciplines of Nursing and Psychology than were referred to the more traditional rehabilitation disciplines of Physiotherapy and Occupational Therapy, even though the latter disciplines were much larger in terms of staff hours. Speech Pathology and Dietetics received very few referrals, but this may have been due, at least in part, to their small size and the limited staff in these disciplines.

Study 3 looked at the injury-related variables of previous TBI, cause of injury, severity of injury and hospitalisation and considered how they were related to participants' initial contact with CRU's clinical services. It was hypothesised that increased service utilisation would be associated with previous TBI, increased severity, assault-related injuries and hospitalisation. The results of this study only supported the association between increased severity of injury and increased service use, although there was also a trend towards an association with previous TBI. The other hypotheses in this study were that those participants who had been hospitalised post-injury would be more likely to be referred to the disciplines of Physiotherapy and Occupational Therapy for assistance with physical injuries, and, based on the results of previous research in USA, that those with mild injuries would be more likely to access psychological services. The results of this study supported the hypothesis that hospitalisation post-injury would be associated with referral to Physiotherapy and Occupational Therapy, although for Occupational Therapy the result did not quite reach statistical significance (p = .013). No association was found between milder injuries and referral to Psychology, but those with more severe injuries were more likely to be referred to Physiotherapy and Occupational Therapy. Assault-related TBI has also been shown to be associated with poorer outcomes. In this study those injured in an assault were not referred to more of CRU’s disciplines, but they were more likely to be referred to Psychology. There was a trend towards those with previous TBI being referred to Psychology, and Nursing tended to give appointments to those with previous TBI. Additionally there was 100% attendance of initial appointments/HVs in Nursing by those who were moderately or severely injured.

Study 4 looked at some indicators of the sample's post-injury functioning, namely PCS symptoms of anxiety and depression and functional independence, and considered how they were related to their initial contact with CRU's clinical services. It was hypothesised that increased service utilisation would be associated with functional dependence, that the sample who were not functionally independent would be more likely to be referred to Occupational Therapy and Physiotherapy for assistance with physical limitations, that those reporting higher levels of PCS would be more likely to be referred to Nursing, and those reporting high levels of psychological symptoms would more likely to be referred to Psychology. This study found that functional dependence was not associated with referral to more services, or referral to Physiotherapy, but there was a strong tendency for those who were not functionally dependence to be referred to Occupational Therapy. The hypothesis that higher levels of PCS would be associated with referral to Nursing was supported, but surprisingly those with higher levels of psychological distress were not more likely to be referred to Psychology at CRU. Significantly, a proportion of those reporting levels of psychological distress in the moderate to severe range were not referred to Psychology, despite the fact that Psychology received referrals for 78% of the whole sample. This may be because CRU’s intake process did not screen for symptoms of anxiety and depression, which previous research suggests may be overlooked in this patient group. However moderate to severe levels of depressive symptoms were associated with referral to Social Work, suggesting a need for support with accessing services in these patients. There was a tendency for those with fewer PCS and lower levels of anxiety to be referred to Occupational Therapy.

Study 5, the final study reported in this thesis, looked further at how rehabilitation services impact on TBI patients' recovery. It aimed to measure the amount and nature of therapy participants received in CRU's seven clinical disciplines, and to consider how the range of variables examined in studies 2, 3 and 4 have impacted on this. Based on the research reviewed in chapter 3 of this thesis and the results obtained in previous studies, it was hypothesised that more hours of therapy across disciplines would be associated with increased severity of injury, a history of TBI and older age, while more hours of therapy in Nursing would be associated with increased age and a history of TBI, and more therapy in Psychology would be associated with moderate to severe symptoms of anxiety and/or depression

The results of study 5 indicated that on average participants received 7.18 hours of therapy across disciplines, with a proportion of therapy in all disciplines being by telephone. The variable associated with increased amounts of therapy across disciplines was age-at-injury. However this association was statistically significant only for the sample age 41 to 59 years, which received the highest amount of therapy, compared with the youngest group (16 to 20 years), which had the shortest therapy times. This result may be due to a number of factors such as different goals and expectations for rehabilitation in the middle aged group, or possibly older participants finding more difficulty attending appointments at CRU, compared to those in younger age brackets. Higher IQ also showed a trend towards association with larger amounts of therapy. Surprisingly no association was found between increased severity of injury and increased hours of therapy. In individual disciplines, higher levels of depressive symptoms were associated with increased therapy in Nursing and in Psychology, while some level of functional dependence and higher levels of PCS were associated with increased therapy in Psychology. Nursing tended to give more therapy to those who were functionally dependent and those with a history of TBI. The average amount of therapy received and the proportions of telephone and face-to-face therapy varied considerably across disciplines, probably reflecting differences in the services offered. The shortest mean therapy time was in Nursing, and the longest in Physiotherapy. Wait times between referral and first contact; and referral and first appointment also varied considerably across disciplines, mainly reflecting variations in staffing levels. Results indicated that, in Psychology at least, the length of time that participants waited to be contacted after their referral to the discipline may impact on their engagement with the service. Home visits were significantly associated with increased hours of therapy in Nursing. The results of this study also suggest that factors such as staffing levels and administrative support may have impacted on participants' engagement with therapy in some of CRU's clinical disciplines.

11.3 Discussion of Main Findings

The current research aimed to investigate how a range of demographic, injury-related and post-injury factors were related to referral to post-acute rehabilitation in a population-based TBI sample. Based on the literature reviewed in chapter 3, it was hypothesised that those who were considered at risk of poorer outcomes would be more likely to be referred for rehabilitation. A range of variables was investigated, but the findings indicated that many of them were not significantly related to referral for rehabilitation either in the public or private sector, through the normal rehabilitation pathways.

Overall the results of study 1 confirm previous research (O'Callaghan, et al., 2009) indicating that rehabilitation for TBI patients is influenced by funding, with those accessing rehabilitation in the private sector better served than those in the public system: Only 4% of the whole TNTR sample was referred for rehabilitation in the public sector by hospital and community services, compared with 20% referred in private. During the period of this research, referral for TBI rehabilitation in the public sector in Tasmania, through the normal rehabilitation pathways, was largely limited to severely injured, hospitalised cases. Furthermore, information about TBI was not routinely available, either for those admitted to the hospital or those discharged from ED. Even though provision of information and reassurance has been shown to be beneficial in preventing ongoing difficulties in mTBI (Alves, et al., 1993; Borg, et al., 2004), there was no system in place for individuals presenting to the ED at the RHH following a TBI to be given any written information, other than the ED information on head injury sheet (Appendix P), which contained only information about what should be done in the first 24 hours post-injury.

This lack of rehabilitation services for those who were not hospitalised is reflected in the model of service delivery for rehabilitation in the public sector proposed in 2003 by the Tasmanian Department of Health and Human Services in its State-wide Strategic Plan for Rehabilitation Services (Department of Health and Human Services, 2003). The rehabilitation phases described in that plan as underpinning service delivery in Tasmania were acute, subacute, re-establishment and community maintenance phases. The model, which is presented in figure 5.2 in chapter 5, shows a linear progression from the inpatient rehabilitation team to the community rehabilitation team and on to community services. No provision was made for non-hospitalised patients to access community rehabilitation, and although there was some scope for referral from the community, the results of study 1 indicate that, for TBI patients at least, this pathway was rarely used: Only three cases from the current sample were referred using this route over a three-and-a half year period. Furthermore there was no system in place in ED or the acute hospital wards to screen for TBI in patients hospitalised for other more urgent medical problems, which meant that in these patients the brain injury could easily be overlooked, as has been found in previous research (Moss & Wade, 1996).

The findings of this first study also indicate that routine follow-up to assess rehabilitation needs of those with moderate and severe TBI, which is recommended in the literature (Turner-Stokes, et al., 2005), and in guidelines for the management of TBI (British Society of Rehabilitation Medicine & Royal College of Physicians, 2003; New Zealand Guidelines Group, 2006), was not occurring. One hundred and twenty four of those who did not access rehabilitation had sustained a moderate or severe TBI. It is possible that some, or all, members of this group had been assessed and found to be not in need of outpatient rehabilitation. However further confirmation of lack of follow-up comes from the fact that 121 individuals, 43 (35%) of whom had suffered a moderate or severe injury, were referred by the TNTR research project itself for public rehabilitation. The referrals were made on the basis of a perceived gap in service provision: TNTR was not intended to provide or refer to clinical services. The fact that these referrals were accepted by the multidisciplinary team at CRU gives validation to the notion that a gap in service provision for this population did exist at this time.

Largely as a result of the referrals by TNTR, the whole sample accessing rehabilitation at CRU contained a significant proportion (52%) of mTBI, non-hospitalised cases (53%) and assault-related injuries (39%). The present research has therefore provided important information about the rehabilitation of those with mild injuries and non-hospitalised cases. The variables associated with referral to rehabilitation by the three groups in study 1 (CRU-TNTR, CRU-Other and Private) are depicted in a flow chart in Figure 11.1. Those associated with referral to public rehabilitation, independently of the TNTR project, were older age (>30 years), hospitalisation, fall-related TBI, increased severity, functional dependence and disability. Significantly 76% had experienced PTA of more than 24 hours and 87% had been hospitalised. Because only 54 cases were referred by this pathway, the 13% of the sample who were not hospitalised represents only 7 cases referred over a three-and-a-half year period. Hospitalisation was typically based on physical deficits, either from the TBI or from comorbid conditions. Those who were in a coma or needed neurosurgical interventions for the TBI, those with high levels of trauma from the injury in which they sustained it, and those with orthopaedic injuries requiring surgery were hospitalised. Following a period of acute hospitalisation a proportion were transferred to the inpatient rehabilitation ward and subsequently referred to CRU for outpatient rehabilitation. Some were referred by physicians directly from the acute wards, and some (16 cases) were referred by the RHH outpatient clinics. As mentioned above, three cases were referred by health professionals in the community.

Referral in the private sector was also associated with hospitalisation, functional dependence, disability and older age, although a smaller percentage of the sample (70%) had been hospitalised compared to those referred in the public system. The majority (73%) had been injured in a transport-related accident, the medical costs of which would have been funded by insurance, due to Tasmania's no-fault system of third-party insurance. The mean PTA of the sample was significantly higher than those not accessing rehabilitation, but there was a relatively large percentage of mTBI (60%), suggesting that many would have been referred for co-morbid injuries as well as, or instead of, the TBI, although specific information is not available about this.

It was hypothesised that, because referrals by TNTR research assistants were made on the basis of a perceived gap in service provision, this group would have higher levels of PCS, pain, fatigue, anxiety and depression, compared to the other groups. These hypotheses were all supported: the TNTR referred group had significantly higher levels of all these symptoms. However the TNTR group was also significantly different in a number of other ways: most notably it contained a large proportion of mild injuries, non-hospitalised cases, assault-related injuries and individuals who had sustained a previous TBI. The TNTR group was also younger than the other two groups and had larger proportions of unemployed participants and participants who had not completed high school, compared to those referred in private and those not accessing rehabilitation. The question of why this group of young, unemployed, less educated, individuals, who were reporting high levels of PCS pain, fatigue and psychological symptoms were not followed up by public rehabilitation services was addressed in study 1: The results of that study suggest that there was no established mechanism in Tasmania whereby individuals with symptomatic TBI, who had not been hospitalised following their injury, could access the services they needed.

Almost half of the TNTR sample had been injured in an assault. In the current research those injured in an assault were significantly more likely to have sustained a mild injury and not to have been admitted to hospital, compared with those injured by other means. As referral in the public system was largely confined to severe injuries and hospitalised cases, it is not surprising that this group was not referred for public rehabilitation. They had not been injured in a transport-related injury, and with low levels of education and high levels of unemployment were unlikely to have private insurance, so referral in the private system was also unlikely. Nevertheless previous research has indicated that those injured in violence related TBI are at risk for poorer outcomes, and more likely to complain of increased PCS, such as headaches, sleep problems, vision and taste disturbances. (Gerhart, et al., 2003; Wenden, et al., 1998b). The TNTR referred sample was reporting significantly higher levels of PCS compared to the other groups. Additionally, a quarter of the TNTR sample had a history of TBI, which previous researchers (Ponsford, et al., 2000; Thornhill, et al., 2000) have found to be associated with reporting of higher levels of PCS from subsequent TBIs, even if they are mild. Although it is well documented (Olver, Ponsford, & Curran, 1996; Ponsford, et al., 1995; Whitnall, et al., 2006) that in the long run it is the cognitive, behavioural and emotional consequences of TBI, not the physical difficulties, which cause the most impairment in psychosocial functioning, there was no system in place to routinely screen for PCS or psychological distress in TBI patients, either in ED or on the wards of the RHH. Some screening may have taken place in outpatient clinics, but there were no guidelines in place to indicate that these factors should be measured in TBI patients, and high levels considered as a possible indicator of rehabilitation need.

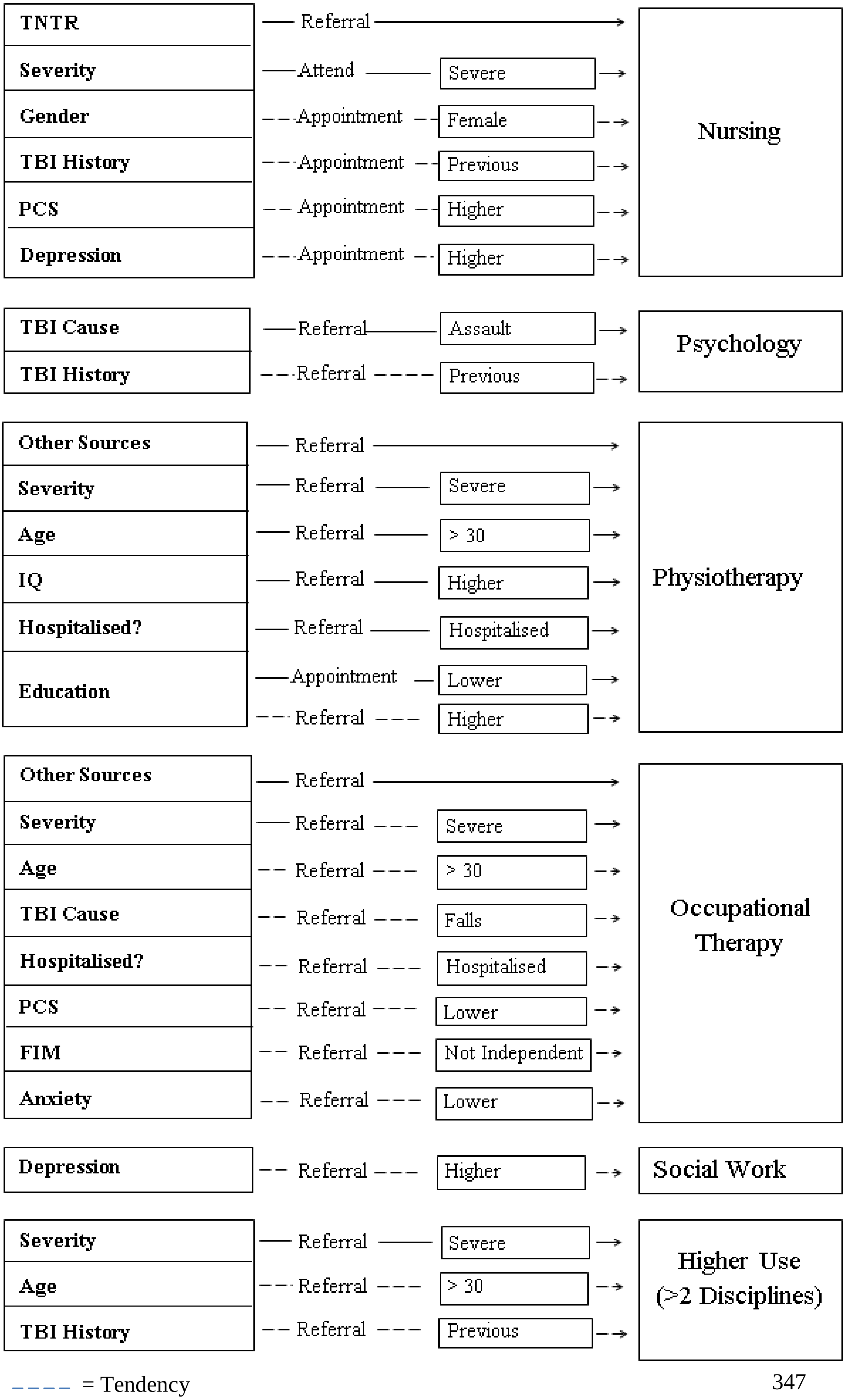
During the period of the current research this gap in services was bridged, albeit in an ad hoc way, by the TNTR research project itself, which referred 121 individuals for public rehabilitation. The project was therefore serving in an informal way as a screen for those participants presenting with high levels of PCS, psychological symptoms, pain, fatigue and distress, a proportion of which were referred for rehabilitation to CRU. However, because the project had not been set up to be a clinical service, this process was not systematised and there was no protocol in place to indicate who should be referred. It is therefore probable that some of those not referred were equally in need of assistance.

These findings point to the importance of systems being in place in acute settings, whereby all patients suspected of a having sustained a TBI are accurately diagnosed and treated, and, when appropriate, referred for rehabilitation. In order for this process to by implemented systematically, protocols need to be developed, based on current research and clinical guidelines, to indicate to medical and allied health staff in these settings what criteria to use to diagnose TBI, and what criteria to use to assess follow-up need in TBI patients.

The aim of studies 2, 3 and 4 of this research was to look at a range of demographic, injury-related and post-injury variables in the sample of the 175 individuals referred to CRU, and investigate how they were related to referral to its seven disciplines. Variables associated with referral to these disciplines are depicted in a flow chart in figure 11.2.

From the proportions of the sample referred to each of CRU's disciplines, as reported in study 2, it is strikingly apparent that many more participants were referred to Nursing and Psychology than were referred to Physiotherapy and Occupational Therapy, even though the latter disciplines were much larger in terms of numbers of staff. This is in contrast with studies of service utilisation (High Jr, et al., 1995; Hodgkinson, et al., 2000; Phillips, et al., 2004) which typically report that traditional rehabilitation disciplines such as physiotherapy, speech pathology and occupational therapy are accessed much more frequently than clinical psychology and counselling. Investigation of possible referral bias in that study indicated that in Nursing this discrepancy may have been due, in part, to the referral of a large proportion of the TNTR sample to Nursing. The reason for this was that the TNTR research assistants were aware that one of the rehabilitation nurses was active in coordinating services for TBI patients, and had a personal interest in the rehabilitation of mTBI. For Psychology, however, a referral bias was not found.

Figure 11.2. Referral, Appointment, Attendance Pathways to CRU Disciplines



Referral of such a large proportion of the sample to Nursing and Psychology, while only one third were referred to Physiotherapy, and a smaller number to Occupational Therapy, can best be explained by the large number of non-hospitalised, mTBI cases referred by TNTR in the current sample, many of whom would not have had deficits requiring physiotherapy or occupational therapy interventions. So, while Nursing and Psychology were providing services for both the more severely injured participants and those with mild injuries, Occupational Therapy and Physiotherapy services were more likely to see those with more severe injuries and those who had been hospitalised post-injury. Notably, as discussed in study 2 and displayed in table 7.4, there was a strong association between referral to CRU from sources other than TNTR, and being subsequently referred to the disciplines of Occupational Therapy and Physiotherapy, but not between referral to CRU from TNTR and subsequent referral to these disciplines. In TBI patients, physiotherapy services are indicated for assessment, diagnosis and treatment of disorders of human movement resulting from the injury or from comorbid problems, such as orthopaedic injuries. These problems are more likely to be necessary for severely injured hospitalised cases. In the current sample, as shown in figure 11.2, TBI patients referred to Physiotherapy were more likely to be severe injuries and to have been hospitalised.

Referrals to Occupational Therapy were also associated with more severe injury and showed a trend towards an association with hospitalisation. However workload factors limited this discipline's ability to accept referrals, and it may also have been that some patients who could have benefited from an Occupational Therapy intervention were not referred, because of its long waiting list. If this was the case, it is likely that those with more severe injuries would have been given priority. It is also possible that the research assistants at TNTR, who were mostly provisionally registered psychologists, may not have had the knowledge to recognise presenting difficulties that could be assisted by an occupational therapy or physiotherapy intervention. As initial referrals to clinical disciplines at CRU were usually made on the basis of the information given on the referral form, this may have resulted in some TBI patients who could have benefited from referral to these disciplines not being referred. This points to the importance of screening patients at the beginning of rehabilitation, in order to fully understand their needs.

Psychology received referrals for the majority of the sample. One reason for this is the diverse range of problems of cognition, behaviour and emotion that TBI patients commonly present with, which can be addressed by a psychological intervention. These include assessment and treatment of cognitive deficits, assistance to patients and families with TBI-related problems, such as challenging behaviours, poor self-care, and adjustment disorders; and assessment and treatment of psychological disorders, such as depression and anxiety. Although there will be some overlap in the assessment and treatment of these conditions, disorders of cognition will commonly be assessed and treated by neuropsychology, while problems with behaviour and emotion will be addressed by clinical psychology.

The description of CRU's clinical services in the State-wide Strategic Plan for Rehabilitation Services in Tasmania (Department of Health and Human Services, 2003) indicates a role for neuropsychology in assessment of cognitive strengths and weaknesses, feedback about assessments to patients, families and treating teams, assistance with the understanding and management of cognitive difficulties and the design and implementation of compensatory strategies. However formal rehabilitation programs to treat or alleviate the functional consequences of cognitive deficits, in areas such as memory, attention and executive function, were outside of the scope of rehabilitation strategies that Psychology was able to provide at CRU. These types of intervention are a standard component of specialised brain injury rehabilitation (Cicerone, et al., 2000; Mazmanian, Kreutzer, Devany, & O'Martin, 1993) and guidelines for TBI rehabilitation, from UK and New Zealand, suggest referral to them for patients with persistent cognitive deficits. Nevertheless, at the time of the current research CRU did not have the resources to provide these types of programs.

Because the disciplines of neuropsychology and clinical psychology were amalgamated in 2005, specific information about the proportions of the sample referred to neuropsychology is not available, but one third of those referred to Psychology (n = 44) received a neuropsychological assessment during their period of rehabilitation at CRU. A post hoc analysis of this sample by the source of their initial referral to the service in study 5 (Appendix W) indicated that those referred by sources other than the TNTR were more likely to receive a neuropsychological assessment than those referred by TNTR: Twenty four percent of those referred by TNTR received a neuropsychological assessment compared with 50% of those referred by other sources. As some of those who were referred for an assessment may not have actually been given one, this suggests that referrers from sources other than TNTR, which were primarily the hospital and its outpatient clinics, may have mainly been referring TBI patients for a neuropsychological assessment, rather than for a clinical psychology assessment or intervention. As outlined in chapter 3 of this thesis, when CRU was established in 2003, psychological services were largely confined to neuropsychological assessment, provided by one staff member who worked one-day a week. In 2004 neuropsychology hours were increased and the services provided by Psychology were expanded by the employment of a part-time clinical psychologist. However medical and allied health staff making referrals from the hospital and its outpatient clinics may have been unaware that CRU was providing clinical psychology services, or uninformed about their relevance to this clinical population. This would be consistent with an Australian study (Hodgkinson, et al., 2000) which found that neuropsychology was the allied health service most frequently accessed in the first two years post-injury, whereas other psychological services were the least accessed. It is interesting, however, that the authors of the same study suggest that psychosocial disability may be a better predictor of service use than physical and cognitive disability.

The establishment of the TNTR research project, and the referral of a large number of non-hospitalised mTBI cases, reporting high levels of PCS, pain, fatigue and psychological problems created an increased demand for psychological services at CRU and may have been a factor in the expansion of this service, which by 2007 was run by the equivalent of two full-time staff. The remaining two thirds of the sample referred for Psychology would most likely have been referred for interventions provided by clinical psychology, although specific information about this is not available. Clinical psychology has a number of important roles in TBI rehabilitation, including assisting patients and families with TBI-related problems and assessment and treatment of comorbid psychological disorders such as anxiety and depression. Surprisingly, although more than half of the whole sample was reporting moderate to severe levels of anxiety, and one third, moderate to severe symptoms of depression, they were not more likely to be referred to psychological services at CRU, and a significant proportion of those reporting higher levels of depression (20%) and/or anxiety (18%) were not referred to Psychology at all. This may be because CRU's intake process did not screen for symptoms of anxiety or depression, which previous research suggests may be overlooked in this patient group (Haggman, et al., 2004; Varney, et al., 1987).

In contrast with these results, those with higher levels of depression were more likely to be referred to the discipline of Social Work, compared with the group reporting normal to mild depressive symptoms. This probably reflects a need in this patient group for social support and the role of Social Work in helping patients, especially those with greater need and limited resources, to access the assistance they require to establish strategies to cope with the disability and life-style change that may result from TBI.

Those injured in an assault were more likely to be referred to Psychology than those injured in other ways. As reviewed in chapter 3, violence-related TBI has been associated with a range of pre-injury factors such as unemployment, low education and substance abuse (Bogner, et al., 2001; Harrison-Felix, et al., 1998) and to result in poorer outcomes such as less community integration and more PCS (Gerhart, et al., 2003). In violence-related TBI, there is a clear role for psychologists to assist with this range of pre-morbid problems, which may have played a part in causing the injury, as well as with the psychosocial consequences of it. This would include assistance with the emotional sequelae of TBI, which is another important role undertaken by clinical psychology at CRU. In mild injuries, in particular, such assistance has been seen as an important part of both prevention and treatment of PCS (Kay, 1993; King, 1996). Adverse self-ratings of emotional well-being have been shown to be clearly related to disability 5 to 7 years post-injury in TBI in a large (n = 475) representative TBI cohort of all severities (Whitnall, et al., 2006), pointing to the potential benefit of psychological interventions, even several years after injury. The tendency for those who had experienced a previous TBI to be referred to Psychology is also consistent with previous research that has found an association between previous TBI and poorer cognitive and psychosocial outcomes (Ewing, et al., 1980; Gronwall & Wrightson, 1975; Ponsford, et al., 2000; Thornhill, et al., 2000) .

These factors help to explain the large number of referrals to Psychology in the current research, compared with the much smaller percentages referred to Occupational Therapy and Physiotherapy. However it is important to note that other researchers have commented on the importance of psychological therapeutic interventions following TBI (Whitnall, et al., 2006), and the incongruity of physiotherapy being the most commonly accessed service in disabled survivors of TBI despite "the predominance of 'mental' sequelae" (Thornhill, et al., 2000, p. 1633). Studies of long-term outcome have also indicated that, in the majority of cases, it is the cognitive, psychological and behavioural, rather than the sensorimotor or physical impairments, which are the most disabling (Hoofien, et al., 2001; Ponsford, et al., 1995).

Most of those referred to CRU were subsequently referred to Nursing, which performed a significant role in the rehabilitation of TBI patients, during the period of the current research. This was due, in large part, to the fact that one of the rehabilitation nurses employed in this discipline worked with the rehabilitation medical specialist, and was active in organising follow-up for TBI patients. A factor that needs to be born in mind when looking at service delivery at CRU is that, as outlined in chapter 4 of this thesis, it was a new service, established in July 2003—only six months before the first referrals for the TBI patients in this research were received. Prior to that date community rehabilitation services were undertaken by two separate agencies in different locations. Some of the gaps in service provision reported in this thesis, such as staff shortages or lack of administrative support, may therefore be a result of the new service adjusting to meet the rehabilitation needs of the community that it serves, as well as the additional unexpected demands for TBI rehabilitation created by the influx of referrals from TNTR. Nevertheless, in order to ensure consistent service delivery, systems need to be put in place that will ensure follow-up, and which are not dependent on the interests or preferences of individual clinicians.

Follow-up by Nursing was frequently by telephone, with this form of therapeutic contact forming one-quarter of Nursing therapy hours. Thirty-nine percent of those referred to Nursing received home visits which may partially explain the 100% attendance of moderate to severe TBI patients for initial Nursing appointments, despite the fact that memory problems have been reported to frequently result in a problems with follow-up in this population (Vakil, 2005). The tendency to give more appointments to women, to those who had experienced a previous TBI and to those with higher levels of depressive symptoms may reflect follow-up of those whom previous research (Farace & Alves, 2000; Gronwall & Wrightson, 1975; Ponsford, et al., 2002; Varney, et al., 1987; Whiteneck, et al., 2004a) has suggested are at risk of poor outcomes. Additionally, those reporting high levels of PCS were more likely to be referred to Nursing than those with lower levels of symptoms. Given that higher levels of PCS are more likely to be reported in milder injuries than in more severe ones (Gordon, et al., 2000; Whiteneck, et al., 2004b), this probably reflects the educative role that Nursing was providing for mTBI patients at CRU, during the period of the current research. .

One of the reasons for the relatively low number of referrals to Occupational Therapy reported in study 2 was the high demand for this service at CRU. As outlined in chapter 5 of this thesis, wait-times were longer for Occupational Therapy than any other discipline except Speech Pathology—which had no staff at all for a period—and referrals were usually restricted to those who were perceived to be in most need of occupational therapy services. Occupational therapy is indicated when a person's health condition limits their ability to carry out activities of everyday life and/or restricts the ability to participate in social, vocational or recreational activities (Department of Health and Human Services, 2003). This includes many diverse activities such as skills for self care, home duties, performance at work or school, driving and leisure; physical rehabilitation to improve co-ordination, strength and movement; cognitive and memory assessment and retraining; home assessment and modification; counselling and education (Occupational Therapy Australia). The discipline of Occupational Therapy at CRU ran both individual and group programs. Group programs included art therapy, woodwork and occasionally a memory rehabilitation group. Occupational Therapy also performed driving assessments. Occupational Therapy services could therefore potentially benefit TBI patients across a range of severities but the waiting list resulted in only those with the greatest need being referred for Occupational Therapy. This was usually those with more severe injuries, as evidenced by the strong association between referral to Occupational Therapy and more severe injuries found in study 3. Results of that study also show that Occupational Therapy tended to receive more referrals for those injured in a fall than from other types of injuries, possibly because of orthopaedic injuries which would require home assessments for things like mobility aids or installation of hand rails.

In contrast with the large proportions of the sample referred to Psychology and Nursing, only seven percent were referred to Speech Pathology. This can be partly explained by the nature of speech pathology services which are only likely to be indicated for TBI patients with more severe injuries and neurological deficits. However, another important factor was staff shortages in this discipline. Although there was provision for 1.4 full-time equivalent staff, for most of the period of the current research there was only one speech pathologist, and for a period of over one year, from March 2005 to November 2006 no service was available at all, due to a state-wide shortage of speech pathologists at that time. These staff shortages are reflected in the long wait times in this discipline for the five participants who were referred during this period: two were not given any appointment and the other three waited an average of seven months to attend one.

Service utilisation (access to services) was significantly associated with injury-severity, with more severely injured individuals referred to more disciplines. This is consistent with a number of studies of service-use post-TBI which have found that those with more severe injuries use more services. (High Jr, et al., 1995; Hodgkinson, et al., 2000). There was also a tendency for patients with a history of TBI to be referred to more disciplines, possibly indicating that they were experiencing more difficulties following their injury, as has been reported in previous research (Ewing, et al., 1980; Ponsford, et al., 2000). There was also a tendency for younger patients to be referred to fewer disciplines, which may be due to fewer difficulties in those who were younger. A large body of research, reviewed in chapter 3 of this thesis, has indicated that older adults experience poorer outcomes following TBI, both as a consequence of direct effects of the injury to the brain (Rothweiler, et al., 1998; Vollmer, et al., 1991) and a higher incidence of comorbid conditions (Goleburn & Golden, 2001). Younger ones would therefore be expected to require fewer services, during the course of their rehabilitation.

Study 5, the last study reported in this thesis, looked at the amount and type of therapy participants received at CRU, as well as details of some of the factors, such as follow-up times between referral and first contact and first appointment, which may have influenced the therapy they received. On average participants received a total of 7.18 hours of therapy. In every discipline a proportion of therapy was by telephone. While the amount of therapy by telephone was very small for some disciplines, such as

Physiotherapy, in others it was significant—notably in Nursing as mentioned above, and Social Work. In each of these disciplines some participants received only telephone therapy.

The results of this study suggest that in Psychology at least, the time participants waited before being contacted by someone from the discipline may have been a factor in their engagement in the service: Those who waited longer were more likely to disengage with the service. Simple administrative procedures such as a letter acknowledging the referral, which was done routinely in some disciplines, may be useful in preventing this. However it may be that this result reflects difficulties contacting some TBI patients referred to Psychology, many of whom were young and unemployed and may not have had a fixed address. Previous research has indicated that factors such as younger age (Snell & Surgenor, 2006) violence-related TBI and socioeconomic disadvantage (Corrigan et al., 2003; Langley, Johnson, Slatyer, Skilbeck, & Bell, 2009) are associated with loss to follow-up in this population. All of these factors were characteristics of the TNTR-referred group, many of whom were subsequently referred to Psychology at CRU.

Home visits, on the other hand, were associated with increased hours of therapy in the whole sample, and in all of the disciplines which practiced them. This difference was statistically significant in Nursing, and verging on significance in Psychology, but not in Social Work and Occupational Therapy, probably due to the small numbers in the latter two disciplines.

The variable associated with increased amounts of therapy across disciplines was age-at-injury. However this association was statistically significant only for the sample age 41 to 59 years, which received the highest amount of therapy, compared with the youngest group (16 to 20 years), which had the shortest therapy times. Surprisingly age over 60 years, which has been shown in numerous studies (Keyser-Marcus, et al., 2002; Vollmer, et al., 1991; Whiteneck, et al., 2004b) to be associated with poorer outcomes, was not associated with increased therapy in this study. The large body of research that points to poorer outcomes in those over 60 years of age, suggest that this finding may be related to difficulties in accessing services and not to service-need, but further research is necessary to confirm this. The reasons why the middle-aged group received the highest amount of therapy may be that this age group are likely to have different goals for rehabilitation—such as return to work—compared with an older population who are more likely to be retired (Turner-Stokes, et al., 2005) and may feel less pressure to try and return to premorbid functioning. In the youngest group shorter amounts of therapy is consistent with the finding that this group was referred to fewer disciplines, and may be due to lack of need. However it may also be due to other factors related to motivation to take part in the rehabilitation process and/or lack of insight into its relevance. This would be consistent with the findings from a concussion clinic in New Zealand for mTBI patients (Snell & Surgenor, 2006) which found that younger patients were more likely to fail to attend appointments than older ones.

The finding from the present study that severity, as measured by PTA, was not associated with more therapy can be seen as consistent with previous research which has shown that disability 12-months or more post-injury is as likely following apparently mild injuries as it is following moderate to severe TBI (Thornhill, et al., 2000). Indeed some researchers (Alexander, 1992; Tellier, et al., 1999) have suggested that it is a misnomer to call a TBI that results in significant and lasting disability" mild". This suggests that when assessing injury-severity other measures, such as severity of PCS or psychological symptoms, also need to be taken into account.

Nevertheless, as reported above, increased severity was associated with referral to more disciplines, suggesting a greater range of difficulties in more severely injured patients, despite the fact that they did not receive more therapy overall. It may be that factors such as lack of insight into their disabilities, or memory problems resulting in forgetting appointments, reduced severely injured participants engagement in therapy in the present research. It is also possible that, because CRU was not able to provide specialist TBI rehabilitation, the services provided there were not commensurate with the difficulties that more severely injured participants presented with.

In study 1, the many differences in the group referred for rehabilitation by the TNTR research project, compared with the group referred to CRU by other sources, gave rise to a question about whether or not this group of mildly-injured TBI patients, with high levels of psychological distress and PCS, would engage with rehabilitation services at CRU. Furthermore the question was asked; if they did engage with the service, would the therapy they received differ, either in its amount or its nature, compared with that received by moderately or severely injured participants?

The finding from study 5 that severity of injury, as measured by PTA, was not associated with the amount of overall therapy participants received at CRU suggests that those with milder injuries were as likely to engage in therapy, as those with more severe injuries. However the results of studies 3 and 5 suggest that the nature of the therapy they received was different. They were referred to fewer disciplines and were less likely to be referred to Occupational Therapy and Physiotherapy than those with more severe injuries. In most cases they would therefore have been referred to Nursing and Psychology, for assistance with PCS and psychological symptoms, and education and reassurance about their injury. This is consistent with findings from study 4 that higher levels of depression and some level of dependence on the FIM—probably due to lack of functional independence on the cognitive rather than the motor items—were associated with increased therapy in both Nursing and Psychology and higher levels of PCS were associated with more therapy hours in Psychology.

Variables that showed a slight trend towards an association with larger amounts of overall therapy were higher IQ and female gender, providing some limited confirmation of previous research which has found a correlation between these variables and compliance with medical treatment. However an additional explanation is that women needed more follow-up because of greater vulnerability to the effects of TBI, as has been suggested by a number of studies (Farace & Alves, 2000; Ponsford, et al., 2000). Further research is necessary to investigate this.

The average amount of therapy received varied considerably across disciplines, reflecting differences in the services offered. The shortest mean therapy time was in Nursing, and the longest in Physiotherapy. This reflects the different services provided by these disciplines. Physiotherapy received much fewer referrals than Nursing, but a proportion may have had persisting long-term orthopaedic problems requiring regular appointments over a number of months. Although therapy in Nursing was brief, this discipline provided an important educative role for TBI patients at CRU, which previous research suggests is particularly beneficial in mild injuries. Thirty percent of participants referred to Nursing received a home visit (HV), and HVs were significantly associated with higher levels of therapy in this discipline. Psychology, gave an average of five hours of therapy to participants, with a significant association between higher levels of therapy in this discipline and higher levels of depressive symptoms as noted above. In Occupational Therapy and Social Work participants received, on average, less than three hours of therapy. While in Occupational Therapy one reason for this lower level of therapy may have been relatively long waiting lists and staff shortages, in

Social Work average hours of therapy may have been lower because of the nature of therapeutic contact in Social Work, which often involved liaison with other services.

In summary, the research reported in this thesis has indicated that referral to public rehabilitation in Tasmania following TBI, through the normal rehabilitation pathways, was largely confined to hospitalised cases and/or moderate to severe injuries. Many of the variables that previous research has found to be associated with poorer outcomes, such as high levels of PCS, psychological symptoms, violence-related aetiology and history of TBI were not predictors of referral to rehabilitation in the public sector. Referral to private rehabilitation encompassed a wider range of injury-severity, but was based on insurance status, and consequently consisted primarily of those injured in motor vehicle accidents. The results of study 1 indicated that no system was in place for those with symptomatic TBI to access assistance if they had not been hospitalised or referred to the RHH outpatient clinics, following their injury. There was also no provision of information and reassurance for mTBI patients in the ED of the RHH, and no systematic method of diagnosing mTBI in patients hospitalised for other injuries. Furthermore the finding that 124 those who received no rehabilitation had suffered either a moderate or a severe injury suggest that routine follow-up to assess rehabilitation needs, which is recommended in the literature and TBI rehabilitation guidelines, was not occurring in Tasmania. The experience of the TNTR research project suggests that this left a gap in service provision, which the project's research assistants attempted to compensate for by referring 121 participants, who were scoring in the moderate to severe range on measures of PCS and psychological symptoms, to CRU for rehabilitation. Forty three members of this group had suffered a moderate or severe injury, giving further confirmation that routine referral of more severe injuries to rehabilitation was not occurring in Tasmania. Given the somewhat ad hoc nature of referral from TNTR it is also probable that there were other participants who were equally distressed, but who were not referred. The acceptance of these referrals by the multidisciplinary team at CRU validates the notion that there was a gap in service provision for TBI patients at this time. These findings point to the importance of systems being in place in acute settings, whereby all patients suspected of a having sustained a TBI are accurately diagnosed, treated and, when appropriate, referred for rehabilitation.

The disciplines of Nursing and Psychology, which were relatively small disciplines in terms of staff hours, received much larger proportions of the sample compared with the larger disciplines of Occupational Therapy and Physiotherapy. For Nursing this can be partly explained by a referral bias for the TNTR referred sample, because one of the rehabilitation nurses was active in coordinating services for TBI patients, largely due to her personal interest in TBI rehabilitation. Nursing performed a significant role in the rehabilitation of TBI because of its proactive approach, using home visits and telephone contact, to ensure timely follow-up for those referred to CRU. However, in order to ensure consistent service delivery, systems need to be put in place that will ensure follow-up and are not dependent on the interests or preferences of individual clinicians.

For Psychology over the period of this research, there was an expansion, from a very limited service offered one day a week, and largely confined to neuropsychological assessment, in 2003 to a service run by the equivalent of two full-time staff, providing both neuropsychological assessment and intervention and clinical psychology in 2007. This is probably due, at least in part, to the large number of non-hospitalised mTBI cases referred by TNTR, who were reporting high levels of PCS, pain, fatigue and psychological problems. Assault-related injuries and previous TBI were associated with referral to Psychology, reflecting the role this discipline can play in assisting with the range of pre-morbid problems that may have given rise to the injury, as well as the psychosocial difficulties resulting from it. Surprisingly, higher levels of anxiety and depression were not associated with referral to Psychology and a proportion of participants reporting these symptoms were not referred to the discipline at all, possibly because CRU's intake process did not screen for these symptoms, which previous research suggests may be overlooked in this patient group.

Referral of such a large proportion of the sample to Psychology and Nursing, while only one third were referred to Physiotherapy, and less to other disciplines, can best be explained by the nature of the clinical services provided by different disciplines and the heterogeneous nature of the sample, which included a significant proportion of mTBI, non-hospitalised cases and assault-related injuries. So for example Nursing and Psychology were providing services for both the more severely injured participants and those with mild injuries, while Occupational Therapy and Physiotherapy services were more likely to see those with more severe injuries and those who had been hospitalised post-injury.

Very few of the participants of the current research were referred to Speech Pathology. This may partly be explained by the nature of its service, which in TBI patients are only likely to be indicated for those with severe injuries and neurological deficits. Nevertheless a prolonged gap in service provision due to staff shortages makes it likely that there was an area of unmet need for this service. Other disciplines, most notably Occupational Therapy also suffered from staff shortages, which often restricted services to those with more severe injuries.

The finding from the present study that severity, as measured by PTA, was not associated with more therapy is consistent with previous research which has shown that disability 12-months or more post-injury is as likely following apparently mild injuries as it is following moderate to severe TBI (Thornhill, et al., 2000). It also points to the importance of measuring other factors such as PCS and psychological symptoms when assessing injury-severity and follow-up need. Nevertheless more severely injured participants were referred to more disciplines than those with milder injuries, indicating a greater range of difficulties overall. Factors such as lack of insight into their disabilities, or difficulties remembering appointments may have limited those with severe injuries from fully engaging in therapy at CRU, or possibly the services available may not have been commensurate with their range of difficulties.

Average hours of therapy varied across disciplines reflecting the different services offered. Nursing offered the briefest therapy but provided an important educative role and used home visits and telephone therapy to proactively follow-up TBI patients referred to the service. There was a slight trend towards those with higher IQ and women to also receive more therapy overall. The variable associated with increased amounts of therapy across disciplines was age-at-injury, with middle-aged (41-59 years) participants receiving significantly more than those less than 30 years of age. This may be due to different goals, such as return to work in the middle-aged sample, Surprisingly, however, the age group that received the highest number of hours of therapy was the age-group 41-59 years and not those 60 years and over. Given the large body of research that points to poorer outcomes in those over 60, this may be related to difficulties in accessing services and not to service-need.

Two questions that arose from the first study in this thesis were; did the group of mildly-injured individuals, with high levels of psychological distress and PCS, referred by TNTR research assistants engage with rehabilitation services at CRU, and, if they did, would the therapy they received differ either in its amount or its nature with that received by more severely injured participants received? The finding that severity of injury, as measured by PTA, was not associated with the amount of overall therapy suggests that these TBI patients were as likely to engage in therapy as those with more severe injuries. However they were referred to fewer disciplines and were more likely to see Nursing or Psychology for assistance with PCS and psychological symptoms than Physiotherapy or Occupational Therapy, for difficulties with physical functioning. This is consistent with previous research which has found that those with mild injuries benefit from education and reassurance.

11.4 Rehabilitation Pathways

The third aim of this research was to increase understanding of TBI and its management, by developing a model of rehabilitation pathways based on the literature reviewed in chapters 2 to 5 of this thesis, and the results of the studies reported in it.

From the discussion of the results of the current research in the preceding section, it is apparent that during the period of the current research there were a number of shortcomings in the system of service delivery for TBI rehabilitation in the public sector in Southern Tasmania, which a proposed model would need to address. These can be summarised as follows:

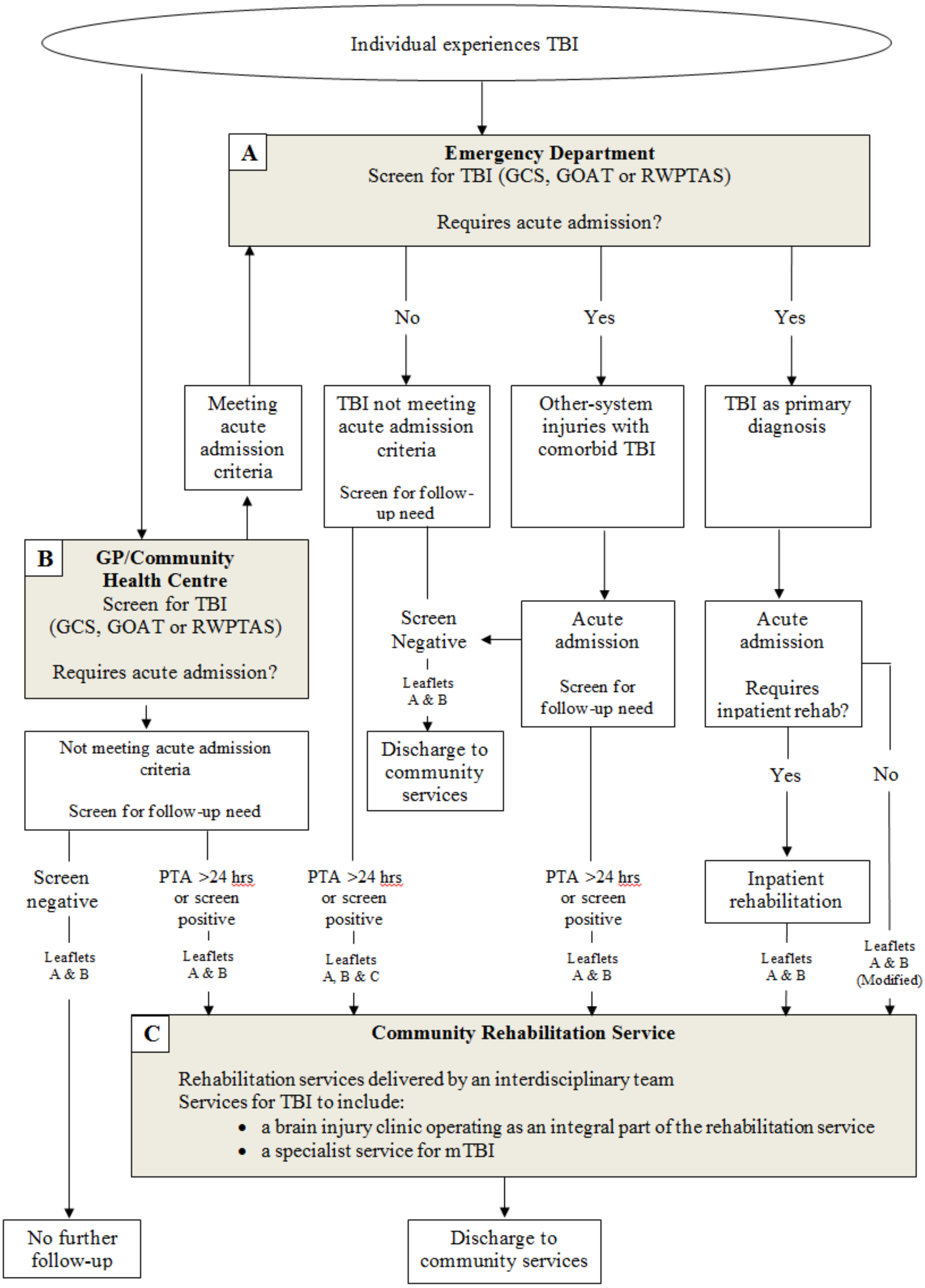
- Referral for TBI rehabilitation was largely limited to hospitalised cases, both in principle, as outlined in the State-wide Strategic Plan for Rehabilitation Services (Department of Health and Human Services, 2003), and in practice, as found in study 1.
- There was no pathway for mild TBI patients to access rehabilitation in the public sector, even if they had high levels of PCS and/or psychological symptoms.
- Even moderate and severe TBI patients were not routinely followed up to assess their need for rehabilitation.

- There was no provision of information and reassurance to mTBI cases presenting to the ED of the RHH, even though this has been shown to be beneficial in all but the mildest TBI (PTA< 1hour and not hospitalised).
- Referral for rehabilitation by medical staff in the RHH and its outpatient clinics was largely on the basis injury-severity (as measured by PTA, GCS or LOC), and was primarily for physiotherapy and occupational therapy.
- When referrals by medical staff in the RHH and its outpatient clinics were made to psychology, this was usually for a neuropsychological assessment. This suggests they may have been unaware that CRU was providing clinical psychology services, or uninformed about their relevance to this clinical population.
- No system was in place to screen TBI patients presenting to acute medical services for PCS or psychological symptoms, even though the literature suggests that those presenting with high levels of these symptoms are at risk for poorer outcomes.
- TBI patients referred to CRU were not given any initial screening questionnaires or assessments to guide their initial referral to its clinical services. This meant that initial referral to clinical disciplines at CRU was largely based on the information given on the referral form, which may not always have been complete or accurate enough to identify all of the patients rehabilitation needs.
- The multidisciplinary team at CRU was not operating at all levels of the ICF framework (World Health Organisation, 2001), because it had very little involvement from specialist medical physicians.
- There was no system to provide follow-up for mTBI cases referred to CRU during the current research. Although in practice follow-up was undertaken by

the discipline of Nursing, this was, at least partly, because of personal interest and not because resources were specifically allocated to it.

- Staffing shortages in some disciplines, particularly Speech Pathology and Occupational Therapy, limited the services available to TIB patients at CRU. While in some disciplines, processes were in place to inform patients of delays, this was not the case in others.

Figure 11.3 Proposed Model of Rehabilitation Services



11.5 Proposed Model of Rehabilitation Pathways

Based on the research summarised in chapters 2 to 5, and the results of studies 1 to 5, an alternative model is proposed as outlined in figure 11.3. This model takes into account the points noted at the end of each chapter.

The results of the current research, confirm previous studies indicating that when assessing the need for rehabilitation following TBI, the whole spectrum of severity must to be considered (King, et al., 1997; National Institutes of Health Consensus Development Panel on Rehabilitation of Persons With Traumatic Brain Injury, 1999), not just hospitalised cases and/or those with moderate to severe injuries. This is because, although the overwhelming majority of mTBI patients recover spontaneously, some have ongoing problems, which can be prevented or ameliorated with early intervention. A key element of the proposed model is therefore provision of information about TBI, and about TBI rehabilitation services, to all patients meeting TBI diagnostic criteria.

Components of the Model

In this model all patients experiencing a TBI are envisioned as presenting to either the Emergency Department (ED) of their local hospital, or their general medical practitioner (GP)/community health centre. These two locations are represented by shaded rectangles, labelled A and B, and described in more detail below:

A. Emergency Department

TBI patients presenting to ED are assessed using routine procedures such as Glasgow Coma Scale (GCS; Jennett, 1976) scores and clinical examination, and those who meet acute admission criteria are admitted to one of the acute wards. This is represented in the model by the two downward pathways on the right hand side:

- Admission with TBI as the primary diagnosis,
- Admission for other-system injuries, with comorbid TBI.

A third pathway, in the centre of the model, represents TBI patients who do not meet ED admission criteria. The criteria used to diagnose TBI in the first two pathways, such as (GCS) scores or the results of CT scans, may not identify these patients, particularly those presenting following a mild injury. For example a GCS score may not differentiate between a mTBI and someone with an injury to the head and no impairment to the brain, because both will be given a score of 15. In order to accurately diagnose TBI in ED, it is therefore necessary to use other criteria, such as a measurement of PTA. This is assessed retrospectively by a measure such as the Galveston Orientation and Amnesia Test (GOAT; Levin, et al., 1979), or prospectively with a measure such as the Revised Westmead PTA Scale (RWPTAS Ponsford, et al., 2004), depending if the patient is presenting immediately post-injury, or sometime after it. These measures are reviewed in Chapter 3.

Where PTA is more than 24 hours, the patient is routinely referred to rehabilitation services for assessment of rehabilitation needs. All other patients who meet diagnostic criteria for TBI are screened in ED for follow-up need. As outlined in chapter 3, one such screen has been developed at St Vincent's Hospital in Sydney (Sheedy, Geffen, Donnelly, & Faux, 2006; Sheedy, et al., 2009). These researchers found that a brief screen, consisting of measures immediate and delayed memory; and severity of injury-related headache, can predict which individuals are at risk of persisting PCS at three-month post-injury, with 80% sensitivity and 76% specificity. The current research suggests that it will also be useful to assess other factors such as previous TBI, a history of psychiatric illness, anxiety and depressive symptoms; and the severity of other PCS, which have all been shown to be associated with poorer outcomes following mTBI. Depending on the results of this screen, patients are either:

- Discharged to community services
- Referred to the Community Rehabilitation Service (represented by a shaded rectangle labelled C in the model) for possible follow-up. This pathway includes all those with PTA of >24 hours.

B. General Practitioner (GP)/Community Health Centre

TBI patients presenting to their GP or community health centre are assessed using routine procedures, such as GCS scores and clinical examination, and those with signs and symptoms indicating that acute admission may be advisable, are sent to ED for further assessment. This is represented in the model by a pathway leading to ED (upward arrow):

- Assessment in ED for possible acute admission

The other pathway from GP/Community Health Centre (downward arrow) represents TBI patients who do not meet acute admission criteria. These patients are assessed using diagnostic tools that will identify mTBI, such as measurement of PTA. As outlined above, this is assessed retrospectively by a measure such as the Galveston Orientation and Amnesia Test (GOAT; Levin, et al., 1979), or prospectively with a measure such as the RWPTAS (Ponsford, et al., 2004), depending if the patient is presenting immediately post-injury, or sometime after it. If the scores on these instruments indicate the patient is still experiencing PTA, they are kept at the health centre, or sent to ED, for ongoing monitoring until PTA is over. Where PTA is more than 24 hours they are routinely referred to rehabilitation services for assessment of rehabilitation needs.

All other patients who meet diagnostic criteria for TBI are screened by their GP/community health workers for follow-up need. As outlined above, one such screen has been developed at St Vincent's Hospital in Sydney (Sheedy, et al., 2006; Sheedy, et al., 2009). The current research suggests that it will also be useful to assess other factors such as previous TBI, a history of psychiatric illness, anxiety and depressive symptoms and the severity of PCS. Depending on the results of this screen patients are either:

- Referred to the Community Rehabilitation Service (represented by a shaded rectangle labelled C in the model) for possible follow-up. This pathway includes all those with PTA of > 24 hours.
- Not given any further follow-up.

Information about TBI and TBI Rehabilitation Services

As reviewed in chapter 4 of this thesis, a number of studies have indicated that early educational information can reduce persistent PCS following mild to moderate TBI (Mittenberg, et al., 2001; Paniak, et al., 1998; Paniak, et al., 2000; Wade, 1997; Wade, et al., 1997). Furthermore, although PCS are commonly associated with mild injuries, research indicates that those with more severe injuries report more symptoms, or increased severity of symptoms over time (Gordon, et al., 2000; Sigurdardottir, et al., 2009). As suggested in study 4, it may therefore be valuable to provide education for all TBI patients, rather than targeting only those who report high levels of PCS on presentation to medical services.

As outlined in chapter 5 of this thesis communication and coordination, at multiple levels of the rehabilitation process, is essential to ensure that the person in rehabilitation progresses through the network of services in a seamless continuum of care (Turner-Stokes, 2002). In particular both previous research in Australia (Turner, et al., 2011), and the current research, indicate that many individuals who could benefit from rehabilitation are unable to gain access to it. For these reasons, the proposed model includes provision of information, about TBI and about TBI rehabilitation services, to patients presenting to ED or to their GP/community medical centre following their injury. All patients would receive:

- **An information leaflet (Leaflet A) about rehabilitation services,** including information about who should contact the service and how this can be done;
- **An information leaflet (Leaflet B) about TBI,** with a description of common symptoms following TBI, strategies to minimise their potentially disabling effects and appropriate reassurance about the expected time-frame for recovery. It would also give information about what things to avoid in the interim period (for example drinking alcohol) and when it would be appropriate to seek further medical advice. The contact details of community rehabilitation services would also be included.

It is important to note that an adapted version of Leaflet B would be used for those with more severe injuries, with information more suited to their needs (for example a longer expected time period for the improvement of symptoms), to avoid giving these patient's an unrealistically short time-frame for recovery which may lead to confusion, anger and discrediting of further advice, if it is not ultimately justified (King, et al., 1997).

Those discharged from ED would also be provided with:

- **ED Discharge Information Sheet (Leaflet C)** with information about what to do in the first 24-hours post-injury, and advice about when to seek further follow-up, either from a GP or by returning to ED.

C. Community Rehabilitation Services.

The proposed model envisages a community rehabilitation service represented by a shaded rectangle labelled C, which includes the following features:

- A manager who ensures the co-ordination of all of its rehabilitation services
- Services delivered by an inter-disciplinary team, with the expertise and skills to undertake assessment and management of person with TBI at all levels of the ICF model (World Health Organisation, 2001). This would include a specialist rehabilitation physician, rehabilitation nurses, neuropsychologists, clinical psychologists, occupational therapists, physiotherapists, speech pathologists and social workers.
- A specialist brain injury clinic to operate as an integral part of the rehabilitation service, rather than as a separate rehabilitation pathway.
- A specialist service for mTBI: for example a concussion clinic with adequate staffing to ensure that mTBI patients are given appropriate reassurance and education in a timely manner, and that when appropriate they are referred to other health professionals within the community rehabilitation service for further intervention.
- Adequate administrative support in order to ensure that patients referred to the service, are contacted in a timely manner.
- Systems to allow patients who are experiencing difficulties, or who need information about TBI, to contact the service quickly and easily (for example a 24-hour answer phone, with quick follow-up when messages are left).
- Adequate assessment procedures at intake to identify all the problems appropriate to be targeted in rehabilitation, and to give a baseline against which outcome can be measured.

- Services for patients that are determined by individualised and documented rehabilitation goals, which are meaningful for the patient and are set within appropriate time-frames.
- Services that are provided in the context most relevant to the patient's goals; so for example provision of services in the home, the work-place and the community, whenever appropriate.
- Methods, such as home visits and telephone reminders, used to ensure that individuals do not miss appointments, because of memory and executive functioning deficits.
- Pro-active strategies used to ensure those with special needs, for example those with lower levels of education, psychiatric difficulties or those who have been injured in violence-related TBI, receive the most appropriate assessment and management.
- Measurements of outcome which are relevant to patients, such as measures of quality of life, productivity and return to work.
- Outcomes are considered in relation to baseline measures collected at intake, to ensure that rehabilitation programs can be continually evaluated
- A formal planned discharge procedure that ensures continuity with community services.

It is important to note that in the proposed model patients are referred to community rehabilitation services to be contacted for possible follow-up, rather than being routinely given an appointment with the service. This is because previous research (King, et al., 1997; Snell & Surgenor, 2006) has indicated that service need is variable, and routine referral may not be the most efficient use of resources. Some individuals may only require advice, information and reassurance, either in person or by telephone, some may need follow-up by one or more disciplines, and others may not be in need of any further intervention.

Rehabilitation Pathways

The proposed model has three possible pathways for TBI patients presenting to ED, and an additional pathway for TBI patients presenting to their GP or community medical centre. These four pathways are described briefly below:

1. **Patients admitted to acute care based on ED TBI criteria.** These patients are those who are assessed as needing acute services for their TBI by ED physicians, and are admitted to one of the acute hospital wards. Following this period of acute care they will be assessed, according to standard hospital practices, to see if they require inpatient rehabilitation. Those who do not require inpatient rehabilitation are referred for community rehabilitation. Those requiring inpatient rehabilitation are routinely referred to community rehabilitation at the end of their inpatient stay. All patients are given Leaflet A and the modified form of Leaflet B described above. Other information appropriate to the severity of their injury could also be given at this time.
2. **Patients admitted to acute care for other system injuries with a co-morbid TBI.** Research (Moss & Wade, 1996) suggests that many mTBI patients admitted for other-system injuries may not have their brain injury diagnosed. In the current model, screening in ED as outlined above would ensure that these patients were identified. They are then screened on the ward, using the instruments described for screening patients in ED or community health centres, to assess whether further follow-up for the TBI is

indicated, and if it is, they are referred for community rehabilitation. All patients are given Leaflet A and Leaflet B.

3. **Patients not meeting ED admission criteria.** Patients who were identified as having experienced a TBI, either from routine ED procedures or from screening measures such as the GOAT or the RWPTAS are further screened to identify whether they need follow-up, as outlined in the section on ED above. Those with a TBI in the moderate or severe category (PTA > 24 hours and/or GCS < 13) are automatically referred to community rehabilitation services. The contact details of those with mTBI, identified as being at risk for poorer outcomes, are given to community rehabilitation services, to be contacted 7—10 days post-injury. All patients are given Leaflet A, Leaflet B and Leaflet C.
4. **Patients presenting to their general practitioner (GP) or community health centre.** Patients presenting to their GP or community health centre following a TBI are screened in the same way as those presenting to ED. Those who are in PTA are either monitored at the health centre until it is over or sent to ED. Those presenting with signs and symptoms which indicate a moderate or severe injury or a complicated mTBI are sent to ED to be further assessed. Those that do not meet these criteria are screened to assess their need for follow-up. The contact details of those who screen positive are given to community rehabilitation services for follow-up, as appropriate. All patients are given Leaflet A and Leaflet B.

11.6 Limitations of the Current Research

Limitations of the current research have been discussed at the end of each of the five studies reported in chapters 6 to 10 of this thesis. They are summarised again briefly here.

In all of the studies reported in this thesis, data were missing on some variables for some participants, because of their refusal or inability to complete some tests and questionnaires at TNTR assessments. More data are missing on the cognitive tests and the measure of premorbid intellectual functioning, than other variables, because, in general, they were more taxing for participants than the collection of demographic and injury-related data.

In study 1, information on participants' previous TBI may have been more complete for the groups referred to CRU (CRU-TNTR and CRU-Other) than the other two groups, because, in some cases, information was obtained on this variable from the referral form, or from correspondence in the CRU clinical files. However this only applies to cases where this information was missing from the participant's medical records. Another limitation of study 1 is that the TBI sample described may not be representative of the whole population of TBI patients in Tasmania, because it contains only those patients who were contactable, and who agreed to participate in the TNTR research project. Although this may have introduced a bias into the current research, it is important to note that the inclusion of non-hospitalised cases does make it more representative of TBI in Australia than studies which include only hospitalised TBI.

Another limitation is the large proportion of cases referred to CRU by TNTR research assistants in the present research, which may limit its ability to be generalised to other services. However, these individuals were referred because they presented with high levels of psychological distress, pain, fatigue and PCS and the referrals were accepted by CRU clinicians. Information about their engagement with CRU's clinical services can therefore provide valuable information that may not be available from other research.

The current research used the FIM (Corrigan, et al., 1997) to measure functional independence, but did not look at its separate items, or take into consideration the two domains—motor and cognitive—which Rasch Analysis (Linacre, et al., 1994) has identified. Consideration of these factors in future studies using the same sample could identify important information about referral patterns in community rehabilitation.

A limitation of study 5 is the retrospective collection of data from clinical files, the accuracy of which will be partially determined by the accuracy of recording by individual clinicians. Additionally, the length of time taken for therapy telephone calls, were a retrospective estimation in most cases because the length of telephone calls was not routinely recorded in the clinical notes.

11.7 Recommendations for Further Research

The findings of this research provide a foundation upon which a number of avenues for further research can be based. These include:

- In the current research, the entire TNTR sample was assessed on a wide-range of measures at regular follow-up points. It would therefore be possible to look at the sample referred to CRU, on some of the variables, such as anxiety and depression scores on the HADS or scores on the RPQ, at a specific follow-up point following their referral to rehabilitation and compare them with their scores at referral. This would enable comparisons to be made on the basis of amounts of therapy given, or on other variables such as severity of injury, in order to give a more accurate picture of the effectiveness of the therapeutic interventions provided at CRU for this clinical group.

- The existence of TNTR data base with baseline and outcome data for a large population-based sample, makes it possible to compare outcomes in a sample from those not referred to rehabilitation (the No-Rehab group from study 1), matched on a range of demographic and pre-injury variables, with the sample referred for public rehabilitation in the current research, or with the sample referred for private rehabilitation. This would facilitate evaluation of the therapeutic interventions provided in rehabilitation, either in the public or private sector.
- The current study was only able to examine broad indicators of TBI patients' engagement with CRU's clinical services: for example number of hours of therapy, and referral or non-referral to its clinical disciplines. Another approach could be that of trialling an intervention, which has been shown to be effective in other community settings, with TBI patients referred to CRU using appropriate baseline and outcome measures.
- Premorbid factors such as alcohol use have been found to be a factor in up to half of all TBIs (National Institutes of Health, 1999). Assault related TBI was very high in the current study. Examination of alcohol use and its relationship to assault-related TBI could yield important information about ways to engage this population with effective TBI rehabilitation and preventative services and programs
- As outlined in chapter 5 of this thesis, the Community Rehabilitation Unit was established in mid 2003, only a few months before the first referrals for the participants of this study were received. Some of the gaps in service

provision may have therefore been due to the fact that it was a new service. The experience of a large number of mild non-hospitalised TBI cases being referred for its rehabilitation services resulted in changes to some of its clinical services. It would therefore be of interest to investigate, possibly using qualitative methods, what was learnt from this experience and in what ways the service has changed and developed over the last eight years since its inception.

- Previous research has indicated that females experience poorer outcomes following TBI. In the current research few significant differences for women and men were found. However there was a slight trend towards women receiving more therapy. Further research in this area could potentially identify if this was due to increased need or greater willingness to comply with therapy.
- The finding that those over the age of 60 did not receive significantly more therapy than the age groups 31 to 40 and 41 to 59 was surprising considering the large body of research outlining poorer outcomes for older adults. More research is needed to ascertain if this result was due to lack of need or inability to access the service.
- Similarly those in the youngest group received the least therapy in the present study. More research is needed to ascertain if this was due to lack of need or lack of engagement with its services for other reasons.

REFERENCES

Aaronson, L. S., Teel, C. S., Cassmeyer, V., Neuberger, G. B., Pallikkathayil, L., Pierce, J., et al. (1999). Defining and measuring fatigue. *Journal of Nursing Scholarship, 31*(1), 45-50.

Alexander, M. P. (1992). Neuropsychiatric correlates of persistent postconcussive syndrome. *Journal of Head Trauma Rehabilitation, 7*(2), 60-69.

Alexander, M. P. (1995). Mild traumatic brain injury: Pathophysiology, natural history, and clinical management. *Neurology, 45*(7), 1253-1260.

Alves, W., Macciocchi, S. N., & Barth, J. T. (1993). Postconcussive symptoms after uncomplicated mild head injury. *Journal of Head Trauma Rehabilitation, 8*(3), 48-59.

American Psychiatric Association. (1980). *Diagnostic and Statistical Manual of Mental Disorders* (III ed.). Washington, DC APA.

American Psychiatric Association. (1994). *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.). Washington, DC: APA.

Australaisan Faculty of Rehabilitation Medicine. (2011). Rehabilitation Service Categories Retrieved 23/6/2011, 2011, from http://www.racp.edu.au/index.cfm?objectid=02A2AB00-EB8A-FDD4-072BC5D23B65D921

Australian Bureau of Statistics. (2008). Recorded Crime: Victims. Retrieved from http://www.ausstats.abs.gov.au/Ausstats/subscriber.nsf/0/2EFA897EF863196CCA2575CA00146304/$File/45100_2008.pdf

Australian Bureau of Statistics. (2011). Tasmanian State and Regional Indicators, Jun 2010. Retrieved from http://www.abs.gov.au/AUSSTATS/abs@.nsf/Previousproducts/1307.6Main%20Features6Jun%202010?opendocument&tabname=Summary&prodno=1307.6&issue=Jun%202010&num=&view=

Baddeley, A. D., & Hitch, G. J. (1974). Working memory. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 9, pp. 47-89). New York: Academic Press.

Banken, J. A. (1985). Clinical utility of considering Digits Forward and Digits Backward as separate components of the Wechsler adult intelligence scale-revised. *Journal of Clinical Psychology, 41*(5), 686-691.

Barth, J. T., Macciocchi, S. N., & Giordani, B. (1983). Neuropsychological sequelae of minor head injury. *Neurosurgery, 13*(5), 529-533.

Bazarian, J. J., Wong, T., Harris, M., Leahey, N., Mookerjee, S., & Dombovy, M. (1999). Epidemiology and predictors of post-concussive syndrome after minor head injury in an emergency population. *Brain Injury, 13*(3), 173-189.

Ben-Yishay, Y., & Diller, L. (1981). Rehabilitation of cognitive and perceptual defects in people with traumatic brain damage. *International Journal of Rehabilitation Research, 4*(2), 208-210.

Ben-Yishay, Y., Silver, S. M., Piasetsky, E., & Rattok, J. (1987). Relationship between employability and vocational outcome after intensive holistic cognitive rehabilitation. *Journal of Head Trauma Rehabilitation, 2*(1), 35-48.

Bigler, E. D., Johnson, S. C., & Blatter, D. D. (1999). Head trauma and intellectual status: Relation to quantitative magnetic resonance imaging findings. *Applied Neuropsychology, 6*(4), 217-225.

Binder, L. M. (1986a). Persisting Symptoms after Mild Head-Injury - a Review of the Postconcussive Syndrome. *Journal of Clinical and Experimental Neuropsychology, 8*(4), 323-346.
Binder, L. M. (1986b). Persisting symptoms after mild head injury: a review of the postconcussive syndrome. *Journal of clinical and experimental neuropsychology : official journal of the International Neuropsychological Society, 8*(4), 323-346.
Binder, L. M., & Rohling, M. L. (1996). Money matters: A meta-analytic review of the effects of financial incentives on recovery after closed-head injury. *American Journal of Psychiatry, 153*(1), 7-10.
Binder, L. M., Rohling, M. L., & Larrabee, G. J. (1997). A review of mild head trauma. Part I: Meta-analytic review of neuropsychological studies. *Journal of Clinical and Experimental Neuropsychology, 19*(3), 421-431.
Bjelland, I., Dahl, A. A., Haug, T. T., & Neckelmann, D. (2002). The validity of the Hospital Anxiety and Depression Scale: An updated literature review. *Journal of Psychosomatic Research, 52*(2), 69-77.
Boake, C., & Diller, L. (2005). History of Rehabilitation for Traumatic Brain Injury In W. M. High, A. M. Sander, M. A. Struchen & K. A. Hart (Eds.), *Rehabilitation for Traumatic Brain Injury* (pp. 3-13). New York,: Oxford University Press.
Boake, C., McCauley, S. R., Pedroza, C., Levin, H. S., Brown, S. A., & Brundage, S. I. (2005). Lost productive work time after mild to moderate traumatic brain injury with and without hospitalization. *Neurosurgery, 56*(5), 994-1002.
Boake, C., Millis, S. R., High W.M, Jr., Delmonico, R. L., Kreutzer, J. S., Rosenthal, M., et al. (2001). Using early neuropsychologic testing to predict long-term productivity outcome from traumatic brain injury. *Archives of Physical Medicine and Rehabilitation, 82*(6), 761-768.
Bogner, J. A., Corrigan, J. D., Mysiw, W. J., Clinchot, D., & Fugate, L. (2001). A comparison of substance abuse and violence in the prediction of long-term rehabilitation outcomes after traumatic brain injury. *Archives of Physical Medicine and Rehabilitation, 82*(5), 571-577.
Bond, M. R. (1975). Assessment of the psychosocial outcome after severe head injury. *Ciba Foundation symposium*(34), 141-157.
Borg, J., Holm, L., Peloso, P. M., Cassidy, J. D., Carroll, L. J., von Holst, H., et al. (2004). Non-surgical intervention and cost for mild traumatic brain injury: Results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. *Journal of Rehabilitation Medicine, 36*, 76-83.
Bornstein, R. A., Miller, H. B., & Van Schoor, J. T. (1989). Neuropsychological deficit and emotional disturbance in head-injured patients. *Journal of Neurosurgery, 70*(4), 509-513.
Bowen, A., Tennant, A., Neumann, V., & Chamberlain, M. A. (2001). Neuropsychological rehabilitation for traumatic brain injury: do carers benefit? [Article]. *Brain Injury, 15*(1), 29-38.
Brain Trauma Foundation. (2006). Guidelines for the surgical management of severe traumatic brain injury. *The Journal of Neurotrauma, May, Supplement 1*.
Brain Trauma Foundation. (2007). Guidelines for the surgical management of traumatic brain injury. *Neurosurgery, March, Supplement*
Brain Trauma Foundation. (2008). *Guidelines for the management of severe traumatic brain injury* (2nd ed.). New York Brain Trauma Foundation

British Society of Rehabilitation Medicine, & Royal College of Physicians. (2003). Rehabilitation following acquired brain injury: National clinical guidelines. London The Lavenham Press.

Brooks, C. A., Lindstrom, J., McCray, J., & Whiteneck, G. G. (1995). Cost of medical care for a population-based sample of persons surviving traumatic brain injury. *Journal of Head Trauma Rehabilitation, 10*(4), 1-13.

Brooks, D. N. (1975). Long and short term memory in head injured patients. *Cortex, 11*(4), 329-340.

Brooks, D. N. (1976). Wechsler Memory Scale performance and its relationship to brain damage after severe closed head injury. *Journal of Neurology Neurosurgery and Psychiatry, 39*(6), 593-601.

Bruckner, F. E., & Randle, A. P. H. (1972). Return to work after severe head injuries. *Rheumatology, 11*(7), 344-348.

Bruns Jr, J., & Hauser, W. A. (2003). The Epidemiology of Traumatic Brain Injury: A Review. *Epilepsia, 44*(SUPPL. 10), 2-10.

Butfield, E., & Zangwill, O. L. (1946). Re-education in aphasia: a reveiw of 70 cases. *Journal of Neurology, Neurosurgery, and Psychiatry, 9*, 217-222.

Cantu, R. C. (1998). Second-impact syndrome. *Clinics in Sports Medicine, 17*(1), 37-44.

Carney, N., Chestnut, R. M., Maynard, H., Mann, N. C. H., Patterson, P., & Helfand, M. (1999). Effect of cognitive rehabilitation on outcomes for persons with traumatic brain injury: A systematic review. *The Journal of Head Trauma Rehabilitation, 14*(3), 277-307.

Carroll, L. J., Cassidy, J. D., Holm, L., Kraus, J., & Coronado, V. G. (2004a). Methodological issues and research recommendations for mild traumatic brain injury: The WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. *Journal of Rehabilitation Medicine, Supplement*(43), 113-125.

Carroll, L. J., Cassidy, J. D., Peloso, P. M., Borg, J., von Holst, H., Holm, L., et al. (2004b). Prognosis for mild traumatic brain injury: Results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. *Journal of Rehabilitation Medicine, 36*, 84-105.

Cassidy, J. D., Carroll, L., Cote, P., Holm, L., & Nygren, A. (2004a). Mild traumatic brain injury after traffic collisions: A population-based inception cohort study. *Journal of Rehabilitation Medicine, Supplement*(43), 15-21.

Cassidy, J. D., Carroll, L. J., Peloso, P. M., Borg, J., von Holst, H., Holm, L., et al. (2004b). Incidence, risk factors and prevention of mild traumatic brain injury: Results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. *Journal of Rehabilitation Medicine, Supplement*(43), 28-60.

Chesnut, R. M., Carney, N., Maynard, H., Mann, N.C., Patterson, P., & Helfand, M. (1999). Summary report: Evidence for the effectiveness of rehabilitation for persons with traumatic brain injury. *The Journal of Head Trauma Rehabilitation, 14*(2), 176.

Christensen, A. L., & Caetano, C. (1996). Alexandr Romanovich Luria (1902-1977): Contributions to neuropsychological rehabilitation. *Neuropsychological Rehabilitation, 6*(4), 279-303.

Cicerone, K. D., Dahlberg, C., Kalmar, K., Langenbahn, D. M., Malec, J. F., Bergquist, T. F., et al. (2000). Evidence-based cognitive rehabilitation: Recommendations for clinical practice. *Archives of Physical Medicine and Rehabilitation, 81*(12), 1596-1615.

Cicerone, K. D., Mott, T., Azulay, J., & Friel, J. C. (2004). Community integration and satisfaction with functioning after intensive cognitive rehabilitation for traumatic brain injury. [Article]. *Archives of Physical Medicine and Rehabilitation, 85*(6), 943-950.

Cifu, D. X., KeyserMarcus, L., Lopez, E., Wehman, P., Kreutzer, J. S., Englander, J., et al. (1997). Acute predictors of successful return to work 1 year after traumatic brain injury: A multicenter analysis. *Archives of Physical Medicine and Rehabilitation, 78*(2), 125-131.

Cohen, M. E., & Marino, R. J. (2000). The tools of disability outcomes research functional status measures. *Archives of Physical Medicine and Rehabilitation, 81*(12 SUPPL. 2), S21-S29.

Collin, C., Wade, D. T., Davies, S., & Horne, V. (1988). The Barthel ADL Index: A reliability study. *International Disability Studies, 10*(2), 61-63.

Collins, M. W., Grindel, S. H., Lovell, M. R., Dede, D. E., Moser, D. J., Phalin, B. R., et al. (1999). Relationship between concussion and neuropsychological performance in college football players. *Journal of the American Medical Association, 282*(10), 964-970.

Cook, J. B. (1972). The post-concussional syndrome and factors influencing recovery after minor head injury admitted to hospital. *Scandinavian Journal of Rehabilitation Medicine, 4*(1), 27-30.

Cope, D. N. (1995). The Effectiveness of Traumatic Brain Injury Rehabilitation - a Review. *Brain Injury, 9*(7), 649-670.

Cope, D. N., & Hall, K. (1982). Head injury rehabilitation: Benefit of early intervention. *Archives of Physical Medicine and Rehabilitation, 63*(9), 433-437.

Corrigan, J. D., Harrison-Felix, C., Bogner, J., Dijkers, M., Terrill, M. S., & Whiteneck, G. (2003). Systematic bias in traumatic brain injury outcome studies because of loss to follow-up. *Archives of Physical Medicine and Rehabilitation, 84*(2), 153-160.

Corrigan, J. D., Smith-Knapp, K., & Granger, C. V. (1997). Validity of the functional independence measure for persons with Traumatic Brain Injury. *Archives of Physical Medicine and Rehabilitation, 78*(8), 828-834.

Coughlan, A. K., & Hollows, S. E. (1985). *The Adult Memory and Information Processing Battery* Leeds: St James' University Hospital

Crawford, J. R., Parker, D. M., & Besson, J. A. O. (1988). Estimation of premorbid intelligence in organic conditions. *British Journal of Psychiatry, 153*(AUG.), 178-181.

Crawford, J. R., Stewart, L. E., Cochrane, R. H. B., Foulds, J. A., Besson, J. A. O., & Parker, D. M. (1989). Estimating premorbid IQ from demographic variables: Regression equations derived from a UK sample. *British Journal of Clinical Psychology, 28*(3), 275-278.

Crepeau, F., & Scherzer, P. (1993). Predictors and Indicators of Work Status Following Traumatic Brain Injury: a Meta-analysis. *Neuropsychological Rehabilitation, 3*(1), 5-35.

Culotta, V. P., Sementilli, M. E., Gerold, K., & Watts, C. C. (1996). Clinicopathological heterogeneity in the classification of mild head injury. *Neurosurgery, 38*(2), 245-250.

De Kruijk, J. R., Leffers, P., Menheere, P. P. C. A., Meerhoff, S., Rutten, J., & Twijnstra, A. (2002). Prediction of post-traumatic complaints after mild traumatic brain injury: Early symptoms and biochemical markers. *Journal of Neurology Neurosurgery and Psychiatry, 73*(6), 727-732.

Dean, T. (2009). Estimation of premorbid intelligence in traumatic brain injury: NART and AUSNART performance in an Australian sample. University of Tasmania
Deary, I. J., Gale, C. R., Stewart, M. C. W., Fowkes, F. G. R., Murray, G. D., Batty, G. D., et al. Intelligence and persisting with medication for two years: Analysis in a randomised controlled trial. *Intelligence*.
Deary, I. J., Gale, C. R., Stewart, M. C. W., Fowkes, F. G. R., Murray, G. D., Batty, G. D., et al. (2009). Intelligence and persisting with medication for two years: Analysis in a randomised controlled trial. *Intelligence, 37*(6), 607-612.
Deb, S., Lyons, I., Koutzoukis, C., Ali, I., & McCarthy, G. (1999). Rate of psychiatric illness 1 year after traumatic brain injury. *American Journal of Psychiatry, 156*(3), 374-378.
Department of Health and Aging. (1994). *Rural, Remote and Metropolitan Areas (RRMA) classification*.
Department of Health and Human Services. (2003). *Statewide Strategic Plan for Rehabilitation Services* Hobart: Tasmanian State Government.
Dikmen, S., & Machamer, J. E. (1995). Neurobehavioral outcomes and their determinants. *Journal of Head Trauma Rehabilitation, 10*(1), 74-86.
Dikmen, S., McLean, A., & Temkin, N. (1986). Neuropsychological and psychosocial consequences of minor head injury. *Journal of Neurology Neurosurgery and Psychiatry, 49*(11), 1227-1232.
Dikmen, S. S., Corrigan, J. D., Levin, H. S., MacHamer, J., Stiers, W., & Weisskopf, M. G. (2009). Cognitive outcome following traumatic brain injury. *Journal of Head Trauma Rehabilitation, 24*(6), 430-438.
Dikmen, S. S., Machamer, J. E., Winn, H. R., & Temkin, N. R. (1995a). Neuropsychological outcome at 1-year post head injury. *Neuropsychology, 9*(1), 80-90.
Dikmen, S. S., Ross, B. L., Machamer, J. E., & Temkin, N. R. (1995b). One year psychosocial outcome in head injury. *Journal of the International Neuropsychological Society : JINS, 1*(1), 67-77.
Dikmen, S. S., Temkin, N., & Armsden, G. (1989). Neuropychological recovery: relationship to psychosocial functioning and postconcussional complaints In H. S. Levin, H. M. Eisenberg & A. L. Benton (Eds.), *Mild Head Injury* New York: Oxford University Press.
Dikmen, S. S., Temkin, N. R., Machamer, J. E., Holubkov, A. L., Fraser, R. T., & Winn, R. (1994). Employment Following Traumatic Head-Injuries. *Archives of Neurology, 51*(2), 177-186.
DiMatteo, M. R. (2004). Variations in patients' adherence to medical recommendations: A quantitative review of 50 years of research. *Medical Care, 42*(3), 200-209.
Dombovy, M. L., & Olek, A. C. (1997). Recovery and rehabilitation following traumatic brain injury. *Brain Injury, 11*(5), 305-318.
Duan, N., Manning, W., Morris, C., & Newhouse, J. A. (1983). A comparison of altrnative models for the demand on health care *Journal of Business and Economic Statistics 1*(2), 115-126.
Ellenberg, J. H., Levin, H. S., & Saydjari, C. (1996). Posttraumatic amnesia as a predictor of outcome after severe closed head injury - Prospective assessment. *Archives of Neurology, 53*(8), 782-791.
Epstein, R. S., & Ursano, R. J. (1994). Anxiety disorders In J. M. Silver, S. C. Yudofsky & R. E. Hales (Eds.), *Neuropsychiatry of traumatic brain injury* (pp. 3-41). Washington DC: American Psychiatric Press.

Ewing, R., McCarthy, D., Gronwall, D., & Wrightson, P. (1980). Persisting effects of minor head injury observable during hypoxic stress. *Journal of Clinical Neuropsychology, 2*(2), 147-155.
Fakhry, S. M., Trask, A. L., Waller, M. A., Watts, D. D., Chendrasekhar, A., & Hammond, J. S. (2004). Management of Brain-Injured Patients by an Evidence-Based Medicine Protocol Improves Outcomes and Decreases Hospital Charges. *Journal of Trauma - Injury, Infection and Critical Care, 56*(3), 492-500.
Fann, J. R., Katon, W. J., Uomoto, J. M., & Esselman, P. C. (1995). Psychiatric disorders and functional disability in outpatients with traumatic brain injuries. *American Journal of Psychiatry, 152*(10), 1493-1499.
Farace, E., & Alves, W. M. (2000). Do women fare worse: A metaanalysis of gender differences in traumatic brain injury outcome. *Journal of Neurosurgery, 93*(4), 539-545.
Fasotti, L., Kovacs, F., Eling, P., & Brouwer, W. H. (2000). Time pressure management as a compensatory strategy training after closed head injury. [Article]. *Neuropsychological Rehabilitation, 10*(1), 47-65.
Faux, S., Sheedy, J., Delaney, R., & Riopelle, R. (2011). Emergency department prediction of post-concussive syndrome following mild traumatic brain injuryan international cross-validation study. *Brain Injury, 25*(1), 14-22.
Fife, D. (1987). Head injury with and without hospital admission: Comparisons of incidence and short-term disability. *American Journal of Public Health, 77*(7), 810-812.
Fleming, J., Tooth, L., Hassell, M., & Chan, W. (1999). Prediction of community integration and vocational outcome 2-5 years after traumatic brain injury rehabilitation in Australia. *Brain Injury, 13*(6), 417-431.
Fortune, N., & Wen, X. (1999). *The definition, incidence and prevalence of acquired brain injury in Australia* Canberra: Australian Institute of Health and Welfare.
Foster, M., Tilse, C., & Fleming, J. (2004). Referral to rehabilitation following traumatic brain injury: Practitioners and the process of decision-making. *Social Science and Medicine, 59*(9), 1867-1878.
Frisch, M. B., Cornell, J., Villanueva, M., & Retzlaff, P. J. (1992). Clinical Validation of the Quality of Life Inventory: A Measure of Life Satisfaction for Use in Treatment Planning and Outcome Assessment. *Psychological Assessment, 4*(1), 92-101.
Gaetz, M. (2004). The neurophysiology of brain injury. *Clinical Neurophysiology, 115*(1), 4-18.
Gennarelli, T. A. (1993). Mechanisms of brain injury. *Journal of Emergency Medicine, 11*(SUPPL. 1), 5-11.
Gennarelli, T. A., Thibault, L. E., & Adams, J. H. (1982). Diffuse axonal injury and traumatic coma in the primate. *Annals of Neurology, 12*(6), 564-574.
Gerhart, K. A., Mellick, D. C., & Weintraub, A. H. (2003). Violence-Related Traumatic Brain Injury: A Population-Based Study. *Journal of Trauma - Injury, Infection and Critical Care, 55*(6), 1045-1053.
Ghaffar, O., McCullagh, S., Ouchterlony, D., & Feinstein, A. (2006). Randomized treatment trial in mild traumatic brain injury. *Journal of Psychosomatic Research, 61*(2), 153-160.
Goldstein, F. C., & Levin, H. S. (2001). Cognitive outcome after mild and moderate traumatic brain injury in older adults. *Journal of Clinical and Experimental Neuropsychology, 23*(6), 739-753.

Goldstein, G., & Watson, J. R. (1989). Test-Retest reliability of the Halstead-Reitan battery and the WAIS in a neuropsychiatric population. *Clinical Neuropsychologist, 3*(3), 265-273.
Goldstein, K. (1942). *Aftereffects of brain injuries in war: Their evaluation and treatment; The application of psychologic methods in the clinic*. New York: Grune & Stratton.
Goleburn, C. R., & Golden, C. J. (2001). Traumatic brain injury outcome in older adults: A critical review of the literature. *Journal of Clinical Geropsychology 7*(3), 161-187.
Gomez-Hernandez, R., Max, J. E., Kosier, T., Paradiso, S., & Robinson, R. G. (1997). Social impairment and depression after traumatic brain injury. *Archives of Physical Medicine and Rehabilitation, 78*(12), 1321-1326.
Goranson, T. E., Graves, R. E., Allison, D., & La Freniere, R. (2003). Community integration following multidisciplinary rehabilitation for traumatic brain injury. [Article]. *Brain Injury, 17*(9), 759-774.
Gordon, W. A., Haddad, L., Brown, M., Hibbard, M. R., & Sliwinski, M. (2000). The sensitivity and specificity of self-reported symptoms in individuals with traumatic brain injury. *Brain Injury, 14*(1), 21-33.
Gordon, W. A., Zafonte, R., Cicerone, K., Cantor, J., Brown, M., Lombard, L., et al. (2006). Traumatic brain injury rehabilitation - State of the science. *American Journal of Physical Medicine & Rehabilitation, 85*(4), 343-382.
Gouvier, W. D., Blanton, P. D., LaPorte, K. K., & Nepomuceno, C. (1987). Reliability and validity of the Disability Rating Scale and the Levels of Cognitive Functioning Scale in monitoring recovery from severe head injury. *Archives of Physical Medicine and Rehabilitation, 68*(2), 94-97.
Graham, S. K., & Cameron, I. D. (2008). A survey of rehabilitation services in Australia. *Australian Health Review, 32*(3), 392-399.
Greenspan, A. I., & Mackenzie, E. J. (2000). Use and need for post-acute services following paediatric head injury. *Brain Injury, 14*(5), 417-429.
Greenspan, A. I., Wrigley, J. M., Kresnow, M., Branche-Dorsey, C. M., & et al. (1996). Factors influencing failue to return to work due to traumatic brain injury. *Brain Injury, 10*(3), 207-218.
Gronwall, D., & Wrightson, P. (1975). Cumulative effect of concussion. *Lancet, 2*(7943), 995-997.
Gronwall, D. M. A. (1977). Paced auditory serial addition task: A measure of recovery from concussion. *Perceptual and Motor Skills, 44*(2), 367-373.
Gualtieri, T., & Cox, D. R. (1991). The delayed neurobehavioural sequelae of traumatic brain injury. *Brain Injury, 5*(3), 219-232.
Guskiewicz, K. M., McCrea, M., Marshall, S. W., Cantu, R. C., Randolph, C., Barr, W., et al. (2003). Cumulative Effects Associated with Recurrent Concussion in Collegiate Football Players: The NCAA Concussion Study. *Journal of the American Medical Association, 290*(19), 2549-2555.
Haffey, W. J., & Abrams, D. L. (1991). Employment outcomes for participants in a brain injury work reentry program: Preliminary findings. *Journal of Head Trauma Rehabilitation, 6*(3), 24-34.
Haggman, S., Maher, C. G., & Refshauge, K. M. (2004). Screening for symptoms of depression by physical therapists managing low back pain. *Physical Therapy, 84*(12), 1157-1166.

Hall, K., Cope, D. N., & Rappaport, M. (1985). Glasgow Outcome Scale and Disability Rating Scale: Comparative usefulness in following recovery in traumatic head injury. *Archives of Physical Medicine and Rehabilitation, 66*(1), 35-37.

Hall, K. M., Hamilton, B. B., Gordon, W. A., & Zasler, N. D. (1993). Characteristics and comparisons of functional assessment indices: Disability rating scale, functional independence measure, and functional assessment measure. *Journal of Head Trauma Rehabilitation, 8*(2), 60-74.

Hall, K. M., Mann, N., High Jr, W. M., Wright, J., Kreutzer, J. S., & Wood, D. (1996). Functional measures after traumatic brain injury: Ceiling effects of FIM, FIM+FAM, DRS, and CIQ. *Journal of Head Trauma Rehabilitation, 11*(5), 27-39.

Hammond, F. M., Grattan, K. D., Sasser, H., Corrigan, J. D., Bushnik, T., & Zafonte, R. D. (2001). Long-term recovery course after traumatic brain injury: A comparison of the Functional Independence Measure and disability rating scale. *Journal of Head Trauma Rehabilitation, 16*(4), 318-329.

Hammond, F. M., Grattan, K. D., Sasser, H., Corrigan, J. D., Rosenthal, M., Bushnik, T., et al. (2004). Five years after traumatic brain injury: A study of individual outcomes and predictors of change in function. [Article]. *Neurorehabilitation, 19*(1), 25-35.

Hanks, R. A., Wood, D. L., Millis, S., Harrison-Felix, C., Pierce, C. A., Rosenthal, M., et al. (2003). Violent traumatic brain injury: Occurrence, patient characteristics, and risk factors from the Traumatic Brain Injury Model Systems project. [Article]. *Archives of Physical Medicine and Rehabilitation, 84*(2), 249-254.

Hanlon, R. E., Demery, J. A., Martinovich, Z., & Kelly, J. P. (1999). Effects of acute injury characteristics on neuropsychological status and vocational outcome following mild traumatic brain injury. *Brain Injury, 13*(11), 873-887.

Harradine, P. G., Winstanley, J. B., Tate, R., Cameron, I. D., Baguley, I. J., & Harris, R. D. (2004). Severe traumatic brain injury in New South Wales: Comparable outcomes for rural and urban residents. *Medical Journal of Australia, 181*(3), 130-134.

Harrison-Felix, C., Zafonte, R., Mann, N., Dijkers, M., Englander, J., & Kreutzer, J. (1998). Brain injury as a result of violence: Preliminary findings from the traumatic brain injury model systems. *Archives of Physical Medicine and Rehabilitation, 79*(7), 730-737.

Haut, M. W., Petros, T. V., Frank, R. G., & Lamberty, G. (1990). Short-term memory processes following closed head injury. *Archives of Clinical Neuropsychology, 5*(3), 299-309.

Hawkins, M. L., Lewis, F. D., & Medeiros, R. S. (2005). Impact of length of stay on functional outcomes of TBI patients. *American Surgeon, 71*(11), 920-929.

Health Department of Victoria, V. (1991). *Summary of Report of 'Head Injury Impact' Project*: Health Department Victoria, Community Services Victoria, & Transport Accident Commission.

Hellawell, D. J., Taylor, R., & Pentland, B. (1999). Cognitive and psychosocial outcome following moderate or severe traumatic brain injury. [Article]. *Brain Injury, 13*(7), 489-504.

Helps, Y., Henley, G., & Harrison, J. (2008). *Hospital separations due to traumatic brain injury, Australia 2004-05*. Canberra: Australian Institute of Health and Welfare.

Hibbard, M. R., Uysal, S., Kepler, K., Bogdany, J., & Silver, J. (1998). Axis I psychopathology in individuals with traumatic brain injury. *Journal of Head Trauma Rehabilitation, 13*(4), 24-39.
High Jr, W. M., Gordon, W. A., Lehmkuhl, L. D., Newton, C. N., Vandergoot, D., Thoi, L., et al. (1995). Productivity and service utilization following traumatic brain injury: results of a survey by the RSA regional TBI centers. *Journal of Head Trauma Rehabilitation, 10*(4), 64-80.
High Jr, W. M., Hall, K. M., Rosenthal, M., Mann, N., Zafonte, R., Cifu, D. X., et al. (1996). Factors affecting hospital length of stay and charges following traumatic brain injury. *Journal of Head Trauma Rehabilitation, 11*(5), 85-96.
Hillier, S. (2003). Community-based rehabilitation improves function of patients with traumatic brain injury. *Australian Journal of Physiotherapy, 49*(4), 277.
Hillier, S. L., Hiller, J. E., & Metzer, J. (1997). Epidemiology of traumatic brain injury in south Australia. *Brain Injury, 11*(9), 649-659.
Hiott, D. W., & Labbate, L. (2002). Anxiety disorders associated with traumatic brain injuries. *NeuroRehabilitation, 17*(4), 345-355.
Hodgkinson, A., Veerabangsa, A., Drane, D., & McCluskey, A. (2000). Service utilization following traumatic brain injury. *Journal of Head Trauma Rehabilitation, 15*(6), 1208-1226.
Holsinger, T., Steffens, D. C., Phillips, C., Helms, M. J., Havlik, R. J., Breitner, J. C. S., et al. (2002). Head injury in early adulthood and the lifetime risk of depression. *Archives of General Psychiatry, 59*(1), 17-22.
Hoofien, D., Gilboa, A., Vakil, E., & Donovick, P. J. (2001). Traumatic brain injury (TBI) 10-20 years later: A comprehensive outcome study of psychiatric symptomatology, cognitive abilities and psychosocial functioning. *Brain Injury, 15*(3), 189-209.
Hoofien, D., Vakil, E., Gilboa, A., Donovick, P. J., & Barak, O. (2002). Comparison of the predictive power of socio-economic variables, severity of injury and age on long-term outcome of traumatic brain injury: Sample-specific variables versus factors as predictors. *Brain Injury, 16*(1), 9-27.
Ingebrigtsen, T., Waterloo, K., Marup-Jensen, S., Attner, E., & Romner, B. (1998). Quantification of post-concussion symptoms 3 months after minor head injury in 100 consecutive patients. *Journal of Neurology, 245*(9), 609-612.
Iverson, G. (2006). Complicated vs uncomplicated mild traumatic brain injury: Acute neuropsychological outcome. *Brain Injury, 20*(13-14), 1335-1344.
Iverson, G. L. (2005). Outcome from mild traumatic brain injury. *Current Opinion in Psychiatry, 18*(3), 301-317.
Iverson, G. L., & McCracken, L. M. (1997). 'Postconcussive' symptoms in persons with chronic pain. *Brain Injury, 11*(11), 783-790.
Jager, T. E., Weiss, H. B., Coben, J. H., & Pepe, P. E. (2000). Traumatic brain injuries evaluated in U.S. emergency departments, 1992- 1994. *Academic Emergency Medicine, 7*(2), 134-140.
Jennett, B. (1976). Assessment of Severity of Head-Injury. *Journal of Neurology Neurosurgery and Psychiatry, 39*(7), 647-655.
Jennett, B. (1998). Epidemiology of head injury. *Archives of Disease in Childhood, 78*(5), 403-406.
Jennett, B., & Bond, M. (1975). Assessment of Outcome after Severe Brain-Damage - Practical Scale. *Lancet, 1*(7905), 480-484.
Jennett, B., & MacMillan, R. (1981). Epidemiology of head injury. *British Medical Journal, 282*(6258), 101-104.

Jennett, B., Teasdale, G., & Braakman, R. (1976). Predicting outcome in individual patients after severe head injury. *Lancet, 1*(7968), 1031-1034.
Johnstone, B., Nossaman, L. D., Schopp, L. H., Holmquist, L., & Rupright, S. J. (2002). Distribution of services and supports for people with traumatic brain injury in rural and urban Missouri. *Journal of Rural Health, 18*(1), 109-117.
Jorge, R. E., Robinson, R. G., Moser, D., Tateno, A., Crespo-Facorro, B., & Arndt, S. (2004). Major Depression Following Traumatic Brain Injury. *Archives of General Psychiatry, 61*(1), 42-50.
Jorge, R. E., Robinson, R. G., Starkstein, S. E., & Arndt, S. V. (1994). Influence of major depression on 1-year outcome in patients with traumatic brain injury. *Journal of Neurosurgery, 81*(5), 726-733.
Kannus, P., Niemi, S., Palvanen, M., & Parkkari, J. (1997). Fall-induced injuries among elderly people [9]. *Lancet, 350*(9085), 1174.
Katzman, R., Brown, T., & Fuld, P. (1983). Validation of a short orientation-memory-concentration test of congestive impairment. *American Journal of Psychiatry, 140*(6), 734-739.
Kay, T. (1993). Neuropsychological treatment of mild traumatic brain injury. *Journal of Head Trauma Rehabilitation, 8*(3), 74-85.
Kay, T., Harrington, D. E., Adams, R., Anderson, T., Berrol, S., Cicerone, K., et al. (1993). Definition of mild traumatic brain injury. *Journal of Head Trauma Rehabilitation, 8*(3), 86-87.
Kay, T., Newman, B., Cavallo, M., Ezrachi, O., & Resnick, M. (1992). Toward a Neuropsychological Model of Functional Disability After Mild Traumatic Brain Injury. *Neuropsychology, 6*(4), 371-384.
Kenny, D. T., Trevorrow, T., Heard, R., & Faunce, G. (2006). Communicating pain: Do people share an understanding of the meaning of pain descriptors? *Australian Psychologist, 41*(3), 213-218.
Kesler, S. R., Adams, H. F., Blasey, C. M., & Bigler, E. D. (2003). Premorbid intellectual functioning, education, and brain size in traumatic brain injury: An investigation of the cognitive reserve hypothesis. *Applied Neuropsychology, 10*(3), 153-162.
Keyser-Marcus, L. A., Bricout, J. C., Wehman, P., Campbell, L. R., Cifu, D. X., Englander, J., et al. (2002). Acute predictors of return to employment after traumatic brain injury: A longitudinal follow-up. *Archives of Physical Medicine and Rehabilitation, 83*(5), 635-641.
Khan, S., Khan, A., & Feyz, M. (2002). Decreased length of stay, cost savings and descriptive findings of enhanced patient care resulting from an integrated traumatic brain injury programme. *Brain Injury, 16*(6), 537-554.
King, N. S. (1996). Emotional, neuropsychological, and organic factors: Their use in the prediction of persisting postconcussion symptoms after moderate and mild head injuries. *Journal of Neurology Neurosurgery and Psychiatry, 61*(1), 75-81.
King, N. S. (2003). Post-concussion syndrome: clarity amid the controversy? *British Journal of Psychiatry, 183*, 276-278.
King, N. S., Crawford, S., Wenden, F. J., Caldwell, F. E., & Wade, D. T. (1999). Early prediction of persisting post-concussion symptoms following mild and moderate head injuries. *British Journal of Clinical Psychology, 38*(1), 15-25.
King, N. S., Crawford, S., Wenden, F. J., Moss, N. E. G., & Wade, D. T. (1994). The Rivermead Post Concussion Symptoms Questionnaire: a measure of symptoms commonly experienced after head injury: A measure of symptoms commonly

experienced after head injury and its reliability. *Journal of Neurology 242*, 587-592.

King, N. S., Crawford, S., Wenden, F. J., Moss, N. E. G., & Wade, D. T. (1995). The Rivermead Post Concussion Symptoms Questionnaire: A measure of symptoms commonly experienced after head injury and its reliability. *Journal of Neurology, 242*(9), 587-592.

King, N. S., Crawford, S., Wenden, F. J., Moss, N. E. G., & Wade, D. T. (1997). Interventions and service need following mild and moderate head injury: The Oxford Head Injury Service. *Clinical Rehabilitation, 11*(1), 13-27.

Kinsella, G. J. (2011). What are the characteristics of traumatic brain injury in older adults? *Brain Impairment, 12*(1), 71-75.

Kraus, J. F. (1987). Epidemiology of head injury. In C. P.R. (Ed.), *Head Injury* (2nd ed.). Baltimore: Williams & Wilkins.

Kraus, J. F., Black, M. A., & Hessol, N. (1984). The incidence of acute brain injury and serious impairment in a defined population. *American Journal of Epidemiology, 119*(2), 186-201.

Kraus, J. F., & McArthur, D. L. (1999). Incidence and prevalence of and costs associated with traumatic brain injury. In M. Rosenthal, E. R. Griffith, K. J. S & P. B (Eds.), *Rehabilitation of the adults and child with traumatic brain injury* (pp. 3-17). Philadelphia: Davis.

Kraus, J. F., Peek-Asa, C., & McArthur, D. (2000). The independent effect of gender on outcomes following traumatic brain injury: a preliminary investigation. *Neurosurgical focus [electronic resource]*. *8*(1).

Kreutzer, J. S., Marwitz, J. H., Walker, W., Sander, A., Sherer, M., Bogner, J., et al. (2003). Moderating factors in return to work and job stability after traumatic brain injury. *Journal of Head Trauma Rehabilitation, 18*(2), 128-138.

Kreutzer, J. S., Seel, R. T., & Gourley, E. (2001). The prevalence and symptom rates of depression after traumatic brain injury: A comprehensive examination. *Brain Injury, 15*(7), 563-576.

Langeluddecke, P. M., & Lucas, S. K. (2004). Evaluation of two methods for estimating premorbid intelligence on the WAIS-III in a clinical sample. *Clinical Neuropsychologist, 18*(3), 423-432.

Langley, J., Johnson, S., Slatyer, M., Skilbeck, C., & Bell, T. (2009). *Issues of attrition in a population study of traumatic brain injury (TBI) followed to 3 years post-trauma* Paper presented at the Health Outcomes Conference 2008: Facilitating Knowledge Exchange and Transfer for a Dynamic Future, Canberra, ACT.

Langley, J., Johnson, S., Slatyer, M., Skilbeck, C. E., & Thomas, M. (2010). Issues of loss to follow-up in a population study of traumatic brain injury (TBI) followed to 3 years post-trauma. *Brain Injury, 24*(7-8), 939-947.

Levin, H. S., Brown, S. A., Song, J. X., McCauley, S. R., Boake, C., Contant, C. F., et al. (2001). Depression and posttraumatic stress disorder at three months after mild to moderate traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology, 23*(6), 754-759.

Levin, H. S., Mattis, S., & Ruff, R. M. (1987). Neurobehavioral outcome following minor head injury: A three-center study. *Journal of Neurosurgery, 66*(2), 234-243.

Levin, H. S., O'Donnell, V. M., & Grossman, R. G. (1979). The Galveston orientation and amnesia test. A practical scale to assess cognition after head injury. *Journal of Nervous and Mental Disease, 167*(11), 675-683.

Levin, H. S., Williams, D. H., Eisenberg, H. M., High Jnr, W. M., & Guinto Jnr, F. C. (1992). Serial MRI and neurobehavioural findings after mild to moderate closed head injury. *Journal of Neurology Neurosurgery and Psychiatry, 55*(4), 255-262.
Lezak, M. D., Howieson, D. B., & Loring, D. W. (2004). *Neuropsychological Assessment* (Fourth ed.). New York Oxford University Press.
Linacre, J. M., Heinemann, A. W., Wright, B. D., Granger, C. V., & Hamilton, B. B. (1994). The structure and stability of the functional independence measure. *Archives of Physical Medicine and Rehabilitation, 75*(2), 127-132.
Lishman, W. A. (1988). Physiogenesis and psychogenesis in the ‚post-concussional syndrome'. *British Journal of Psychiatry, 153*(OCT.), 460-469.
Lowdon, I. M. R., Briggs, M., & Cockin, J. (1989). Post-concussional symptoms following minor head injury. *Injury, 20*(4), 193-194.
Macciocchi, S. N., Barth, J. T., Alves, W., Rimel, R. W., & Jane, J. A. (1996). Neuropsychological functioning and recovery after mild head injury in collegiate athletes. *Neurosurgery, 39*(3), 510-514.
Malec, J. F. (2001). Impact of comprehensive day treatment on societal participation for persons with acquired brain injury. [Article]. *Archives of Physical Medicine and Rehabilitation, 82*(7), 885-895.
Martland, H. S., & Beling, C. C. (1929). Traumatic cerebral Hemorrhage. *Archives of Neurology and Psychiatry, 22*(5), 1001-1023.
Matser, E. J. T., Kessels, A. G. H., Jordan, B. D., Lezak, M. D., & Troost, J. (1998). Chronic traumatic brain injury in professional soccer players. *Neurology, 51*(3), 791-796.
Mazaux, J. M., & Richer, E. (1998). Rehabilitation after traumatic brain injury in adults. *Disability and Rehabilitation, 20*(12), 435-447.
Mazmanian, P. E., Kreutzer, J. S., Devany, C. W., & O'Martin, K. (1993). A survey of accredited and other rehabilitation facilities: Education, training and cognitive rehabilitation in brain-injury programmes. *Brain Injury, 7*(4), 319-331.
McCrea, M. (2008). *Mild traumatic brain injury and postconcussion syndrome*. Oxford Oxford University Press
McCrea, M., Guskiewicz, K. M., Marshall, S. W., Barr, W., Randolph, C., Cantu, R. C., et al. (2003). Acute Effects and Recovery Time Following Concussion in Collegiate Football Players: The NCAA Concussion Study. *Journal of the American Medical Association, 290*(19), 2556-2563.
McCullagh, S., & Feinstein, A. (2003). Outcome after mild traumatic brain injury: An examination of recruitment bias. *Journal of Neurology Neurosurgery and Psychiatry, 74*(1), 39-43.
McElligott, J., Carroll, A., Morgan, J., MacDonnell, C., Neumann, V., Gutenbrunner, C., et al. (2011). European models of multidisciplinary rehabilitation services for traumatic brain injury. *American Journal of Physical Medicine and Rehabilitation, 90*(1), 74-78.
McLennan, W. (1997). *Australian Standard Classification of Occupations (ASCO)*.
McMillan, T. M., Jongen, E. L. M. M., & Greenwood, R. J. (1996). Assessment of post-traumatic amnesia after severe closed head injury: Retrospective or prospective? *Journal of Neurology Neurosurgery and Psychiatry, 60*(4), 422-427.
McPherson, G. (1990). *Statistics in scientific investigation: its basis, application, and interpretation* New York Springer-Verlag.
Meerhoff, S. R. H. E. M., De Kruijk, J. R., Rutten, J., Leffers, P., & Twijnstra, A. (2000). The incidence of traumatic head or brain injury in the catchment area of

the Academic Hospital Maastricht in 1997. *De incidentie van traumatisch schedel- of hersenletsel in het adherentiegebied van het Academisch Ziekenhuis Maastricht in 1997, 144*(40), 1915-1918.

Mellick, D., Gerhart, K. A., & Whiteneck, G. G. (2003). Understanding outcomes based on the post-acute hospitalization pathways followed by persons with traumatic brain injury. *Brain Injury, 17*(1), 55-71.

Meltzer, H., Gill, B., Petticrew, M., & Hinds, K. (1995). *The prevalence of psychiatric morbidity in Great Britain*. London Her Majesty's Stationary Office.

Milne, P., & Eagar, K. (2007). *Rehabilitation services in Tasmania: current situation and future plans*: Centre for health Service Development
University of Woollongong.

Mittenberg, W., Canyock, E. M., Condit, D., & Patton, C. (2001). Treatment of post-concussion syndrome following mild head injury. *Journal of Clinical and Experimental Neuropsychology, 23*(6), 829-836.

Mittenberg, W., & Strauman, S. (2000). Diagnosis of mild head injury and the postconcussion syndrome. *Journal of Head Trauma Rehabilitation, 15*(2), 783-791.

Moffatt, S., & Poynton, S. (2006). Long-term trends in property and violent crime in New South Wales: 1990-2004. *Crime & Justice Bulletin*(93), 1-7.

Mooney, G., & Speed, J. (2001). The association between mild traumatic brain injury and psychiatric conditions. *Brain Injury, 15*(10), 865-877.

Moore, E. L., Terryberry-Spohr, L., & Hope, D. A. (2006). Mild traumatic brain injury and anxiety sequelae: A review of the literature. *Brain Injury, 20*(2), 117-132.

Moss, N. E., Powers, D., & Wade, D. T. (1996). The Oxfordshire Head Injury Register. *Disability and Rehabilitation, 18*(4), 169-173.

Moss, N. E. G., & Wade, D. T. (1996). Admission after head injury: How many occur and how many are recorded? *Injury, 27*(3), 159-161.

Motor Accident Authority of New South Wales. (2008). *Guidelines for mild traumatic brain injury following closed head injury*. Sydney: Motor Accident Authority

Murphy, L., Chamberlain, E., Weir, J., Berry, A., Nathaniel-James, D., & Agnew, R. (2006). Effectiveness of vocational rehabilitation following acquired brain injury: Preliminary evaluation of a UK specialist rehabilitation programme. *Brain Injury, 20*(11), 1119-1129.

National Institutes of Health. (1999). Rehabilitation of Persons With Traumatic Brain Injury, *Consensus Conference* (Vol. 282, pp. 974-983): American Medical Association

National Institutes of Health Consensus Development Panel on Rehabilitation of Persons With Traumatic Brain Injury. (1999). Rehabilitation of Persons With Traumatic Brain Injury, *Consensus Conference* (Vol. 282, pp. 974-983): American Medical Association

Neisser, U., Boodoo, G., Bouchard Jr, T. J., Boykin, A. W., Brody, N., Ceci, S. J., et al. (1996). Intelligence: Knowns and Unknowns. *American Psychologist, 51*(2), 77-101.

Nelson, H. E. (1982). *National Adult Reading Test (NART): Test Manual* Windsor, UK: NFER-Nelson

New Zealand Guidelines Group. (2006). Traumatic Brain Injury: Diagnosis, Acute Management and Rehabilitation. Wellington, New Zealand Accident Compensation Corporation.

Novack, T. A., Bush, B. A., Meythaler, J. M., & Canupp, K. (2001). Outcome after traumatic brain injury: Pathway analysis of contributions from premorbid, injury

severity, and recovery variables. *Archives of Physical Medicine and Rehabilitation, 82*(3), 300-305.
O'Callaghan, A. M., McAllister, L., & Wilson, L. (2009). Sixteen years on: Has quality of care for rural and non-compensable traumatic brain injury clients improved? *Australian Journal of Rural Health, 17*(3), 119-123.
O'Callaghan, A. M., McAllister, L., & Wilson, L. (2010). Experiences of care reported by adults with traumatic brain injury. *International Journal of Speech-Language Pathology, 12*(2), 107-123.
O'Connor, P. (2002). *Hospitalisation due to traumatic brain injury* Canberra: Australian Institute of Health and Welfare
Occupational Therapy Australia. What services do occupational therapists provide? Retrieved 16th June 2011, from http://www.ausot.com.au/inner.asp?relid=7&pageid=130
Oddy, M., Humphrey, M., & Uttley, D. (1978). Subjective impairment and social recovery after closed head injury. *Journal of Neurology Neurosurgery and Psychiatry, 41*(7), 611-616.
Olver, J. H., Ponsford, J. L., & Curran, C. A. (1996). Outcome following traumatic brain injury: A comparison between 2 and 5 years after injury. *Brain Injury, 10*(11), 841-848.
Ommaya, A. K., & Gennarelli, T. A. (1974). Cerebral concussion and traumatic unconsciousness. Correlation of experimental and clinical observations on blunt head injuries. *Brain, 97*(4), 633-654.
Oppenheimer, D. R. (1968). Microscopic lesions in the brain following head injury. *Journal of Neurology Neurosurgery and Psychiatry, 31*(4), 299-306.
Ottenbacher, K. J., Hsu, Y., Granger, C. V., & Fiedler, R. C. (1996). The reliability of the functional independence measure: A quantitative review. *Archives of Physical Medicine and Rehabilitation, 77*(12), 1226-1232.
Ownsworth, T., & McKenna, K. (2004). Investigation of factors related to employment outcome following traumatic brain injury: a critical review and conceptual model. *Disability and Rehabilitation, 26*(13), 765-784.
Paniak, C., Phillips, K., Toller-Lobe, G., Durand, A., & Nagy, J. (1999). Sensitivity of three recent questionnaires to mild traumatic brain injury-related effects. *Journal of Head Trauma Rehabilitation, 14*(3), 211-219.
Paniak, C., Reynolds, S., Phillips, K., Toller-Lobe, G., Melnyk, A., & Nagy, J. (2002). Patient complaints within 1 month of mild traumatic brain injury: A controlled study. *Archives of Clinical Neuropsychology, 17*(4), 319-334.
Paniak, C., Toller-Lobe, G., Durand, A., & Nagy, J. (1998). A randomized trial of two treatments for mild traumatic brain injury. *Brain Injury, 12*(12), 1011-1023.
Paniak, C., Toller-Lobe, G., Reynolds, S., Melnyk, A., & Nagy, J. (2000). A randomized trial of two treatments for mild traumatic brain injury: 1 year follow-up. *Brain Injury, 14*(3), 219-226.
Phillips, V. L., Greenspan, A. I., Stringer, A. Y., Stroble, A. K., & Lehtonen, S. (2004). Severity of injury and service utilization following traumatic brain injury: The first 3 months. *Journal of Head Trauma Rehabilitation, 19*(3), 217-225.
Pignone, M. P., Gaynes, B. N., Rushton, J. L., Burchell, C. M., Orleans, C. T., Mulrow, C. D., et al. (2002). Screening for depression in adults: A summary of the evidence for the U.S. Preventive Services Task Force. *Annals of Internal Medicine, 136*(10), 765-776.
Ponsford, J. (1995). *Traumatic Brain Injury: Rehabilitation for Everyday Adaptive Living* Hove UK Psychology Press Ltd.

Ponsford, J. (2005). Rehabilitation interventions after mild head injury. *Current Opinion in Neurology, 18*(6), 692-697.

Ponsford, J., Facem, P. C., Willmott, C., Rothwell, A., Kelly, A. M., Nelms, R., et al. (2004). Use of the Westmead PTA scale to monitor recovery of memory after mild head injury. *Brain Injury, 18*(6), 603-614.

Ponsford, J., & Kinsella, G. (1992). Attentional deficits following closed-head injury. *Journal of Clinical and Experimental Neuropsychology, 14*(5), 822-838.

Ponsford, J., Willmott, C., Rothwell, A., Cameron, P., Ayton, G., Nelms, R., et al. (2001). Impact of early intervention on outcome after mild traumatic brain injury in children. *Pediatrics, 108*(6), 1297-1303.

Ponsford, J., Willmott, C., Rothwell, A., Cameron, P., Kelly, A. M., Nelms, R., et al. (2002). Impact of early intervention on outcome following mild head injury in adults. *Journal of Neurology Neurosurgery and Psychiatry, 73*(3), 330-332.

Ponsford, J., Willmott, C., Rothwell, A., Cameron, P., Kelly, A. M., Nelms, R., et al. (2000). Factors influencing outcome following mild traumatic brain injury in adults. *Journal of the International Neuropsychological Society, 6*(5), 568-579.

Ponsford, J. L., Olver, J. H., Curran, C., & Ng, K. (1995). A profile of outcome: 2 years after traumatic brain injury. *Brain Injury, 9*(1), 1-10.

Poser, U., Kohler, J. A., & Schönle, P. W. (1996). Historical review of neuropsychological rehabilitation in Germany. *Neuropsychological Rehabilitation, 6*(4), 257-278.

Potter, S., Leigh, E., Wade, D., & Fleminger, S. (2006). The Rivermead Post Concussion Symptoms Questionnaire: A confirmatory factor analysis. *Journal of Neurology, 253*(12), 1603-1614.

Powell, J., Heslin, J., & Greenwood, R. (2002). Community based rehabilitation after severe traumatic brain injury: A randomised controlled trial. *Journal of Neurology Neurosurgery and Psychiatry, 72*(2), 193-202.

Powell, J. H., Beckers, K., & Greenwood, R. J. (1998). Measuring progress and outcome in community rehabilitation after brain injury with a new assessment instrument - The BICRO-39 scales. *Archives of Physical Medicine and Rehabilitation, 79*(10), 1213-1225.

Prigatano, G. P., Fordyce, D. J., & Zeiner, H. K. (1984). Neuropsychological rehabilitation after closed head injury in young adults. *Journal of Neurology Neurosurgery and Psychiatry, 47*(5), 505-513.

Ragnarsson, K. T. (2006). Traumatic brain injury research since the 1998 NIH Consensus Conference - Accomplishments and unmet goals. [Article]. *Journal of Head Trauma Rehabilitation, 21*(5), 379-387.

Rao, V., & Lyketsos, C. G. (2002). Psychiatric aspects of traumatic brain injury. *Psychiatric Clinics of North America, 25*(1), 43-69.

Rapoport, M. J., McCullagh, S., Streiner, D., & Feinstein, A. (2003). The clinical significance of major depression following mild traumatic brain injury. *Psychosomatics, 44*(1), 31-37.

Rappaport, M., Hall, K. M., Hopkins, K., Belleza, T., & Cope, D. N. (1982). Disability Rating-Scale for Severe Head Trauma - Coma to Community. *Archives of Physical Medicine and Rehabilitation, 63*(3), 118-123.

Reynolds, S., Paniak, C., Toller-Lobe, G., & Nagy, J. (2003). A longitudinal study of compensation-seeking and return to work in a treated mild traumatic brain injury sample. *Journal of Head Trauma Rehabilitation, 18*(2), 139-147.

Rimel, R. W., Giordani, B., & Barth, J. T. (1981). Disability caused by minor head injury. *Neurosurgery, 9*(3), 221-228.

Rothweiler, B., Temkin, N. R., & Dikmen, S. S. (1998). Aging effect on psychosocial outcome in traumatic brain injury. *Archives of Physical Medicine and Rehabilitation, 79*(8), 881-887.
Roy, C. W., Pentland, B., & Miller, J. D. (1986). The causes and consequences of minor head injury in the elderly. *Injury, 17*(4), 220-223.
Ruff, R. (2005). Two decades of advances in understanding of mild traumatic brain injury. *Journal of Head Trauma Rehabilitation, 20*(1), 5-18.
Ruff, R. M., & Jurica, P. (1999). In search of a unified definition for mild traumatic brain injury. *Brain Injury, 13*(12), 943-952.
Ruff, R. M., Marshall, L. F., Crouch, J., Klauber, M. R., Levin, H. S., Barth, J., et al. (1993). Predictors of Outcome Following Severe Head Trauma - Follow-up Data from the Traumatic-Coma-Data-Bank. *Brain Injury, 7*(2), 101-111.
Ruffolo, C. F., Friedland, J. F., Dawson, D. R., Colantonio, A., & Lindsay, P. H. (1999). Mild traumatic brain injury from motor vehicle accidents: Factors associated with return to work. *Archives of Physical Medicine and Rehabilitation, 80*(4), 392-398.
Russell, W. R. (1968). The development of grand mal after missle wounds of the brain. *The Johns Hopkins medical journal, 122*(5), 250-253.
Russell, W. R., & Smith, A. (1961a). Post-Traumatic Amnesia in Closed Head Injury. *Archives of Neurology, 5*(1), 4-&.
Russell, W. R., & Smith, A. (1961b). Post-Traumatic Amnesia in Closed Head Injury. *Archives of Neurology, 5*(1), 16-29.
Rutherford, W. H., Merrett, J. D., & McDonald, J. R. (1979). Symptoms at one year following concussion from minor head injuries. *Injury, 10*(3), 225-230.
Satz, P. (1993). Brain Reserve Capacity on Symptom Onset After Brain Injury: A Formulation and Review of Evidence for Threshold Theory. *Neuropsychology, 7*(3), 273-295.
Scherzer, B. P. (1986). Rehabilitation following severe head trauma: Results of a three-year program. *Archives of Physical Medicine and Rehabilitation, 67*(6), 366-374.
Schootman, M., & Fuortes, L. (1999). Functional status following traumatic brain injuries: Population-based rural-urban differences. *Brain Injury, 13*(12), 995-1004.
Schretlen, D. J., & Shapiro, A. M. (2003). A quantitative review of the effects of traumatic brain injury on cognitive functioning. *International Review of Psychiatry, 15*(4), 341-349.
Seale, G. S., Caroselli, J. S., High, W. H., Becker, C. L., Neese, L. E., & Scheibel, R. (2002). Use of the Community Integration Questionnaire (CIQ) to characterize changes in functioning for individuals with traumatic brain injury who participated in a post-acute rehabilitation programme. [Article]. *Brain Injury, 16*(11), 955-967.
Semlyen, J. K., Summers, S. J., & Barnes, M. P. (1998). Traumatic brain injury: Efficacy of multidisciplinary rehabilitation. *Archives of Physical Medicine and Rehabilitation, 79*(6), 678-683.
Sheedy, J., Geffen, G., Donnelly, J., & Faux, S. (2006). Emergency Department assessment of mild traumatic brain injury and prediction of post-concussion symptoms at one month post injury. *Journal of Clinical and Experimental Neuropsychology, 28*(5), 755-772.
Sheedy, J., Harvey, E., Faux, S., Geffen, G., & Shores, E. A. (2009). Emergency department assessment of mild traumatic brain injury and the prediction of

postconcussive symptoms: A 3-month prospective study. *Journal of Head Trauma Rehabilitation, 24*(5), 333-343.

Sherer, M., Nick, T. G., Sander, A. M., Hart, T., Hanks, R., Rosenthal, M., et al. (2003). Race and productivity outcome after traumatic brain injury - Influence of confounding factors. *Journal of Head Trauma Rehabilitation, 18*(5), 408-424.

Sherer, M., Novack, T. A., Sander, A. M., Struchen, M. A., Alderson, A., & Thompson, R. N. (2002a). Neuropsychological assessment and employment outcome after traumatic brain injury: A review. *Clinical Neuropsychologist, 16*(2), 157-178.

Sherer, M., Sander, A. M., Nick, T. G., High, W. M., Malec, J. F., & Rosenthal, M. (2002b). Early cognitive status and productivity outcome after traumatic brain injury: Findings from the TBI model systems. *Archives of Physical Medicine and Rehabilitation, 83*(2), 183-192.

Shores, E. A., Marosszeky, J. E., Sandanam, J., & Batchelor, J. (1986). Preliminary validation of a clinical scale for measuring the duration of post-traumatic amnesia. *Medical Journal of Australia, 144*(11), 569-572.

Sigurdardottir, S., Andelic, N., Roe, C., Jerstad, T., & Schanke, A. K. (2009). Post-concussion symptoms after traumatic brain injury at 3 and 12 months post-injury: A prospective study. *Brain Injury, 23*(6), 489-497.

Silver, J. M., Kramer, R., Greenwald, S., & Weissman, M. (2001). The association between head injuries and psychiatric disorders: Findings from the New Haven NIMH Epidemiologic Catchment Area Study. *Brain Injury, 15*(11), 935-945.

Smith, P. M., Illig, S. B., Fielder, R. C., Hamilton, B. B., & Ottenbacher, K. J. (1996). Intermodal agreement of follow-up telephone functional assessment using the functional independence measure in patients with stroke. *Archives of Physical Medicine and Rehabilitation, 77*(5), 431-435.

Snell, D. L., & Surgenor, L. J. (2006). An analysis of referees and referrals to a specialist concussion clinic in New Zealand. *New Zealand Medical Journal, 119*(1231).

Sohlberg, M. M., McLaughlin, K. A., Pavese, A., Heidrich, A., & Posner, M. I. (2000). Evaluation of attention process training and brain injury education in persons with acquired brain injury. *Journal of Clinical and Experimental Neuropsychology, 22*(5), 656-676.

Sosin, D. M., Sniezek, J. E., & Thurman, D. J. (1996). Incidence of mild and moderate brain injury in the United States, 1991. *Brain Injury, 10*(1), 47-54.

Spreen, O., & Strauss, E. (1998). *A compendium of neuropsychological tests*. Oxford: Oxford University Press.

Strauss, E., Sherman, E. M. S., & Spreen, O. (2006). *A compendium of Neuropsychological LTests: Administration, Norms and Commentary* (3rd ed.). New York Oxford University Press.

Stucki, G., Ewert, T., & Cieza, A. (2003). Value and application of the ICF in rehabilitation medicine. *Disability & Rehabilitation, 25*(11/12), 628.

Stulemeijer, M., Van Der Werf, S., Borm, G. F., & Vos, P. E. (2008). Early prediction of favourable recovery 6 months after mild traumatic brain injury. *Journal of Neurology, Neurosurgery and Psychiatry, 79*(8), 936-942.

Susman, M., DiRusso, S. M., Sullivan, T., Risucci, D., Nealon, P., Cuff, S., et al. (2002). Traumatic brain injury in the elderly: Increased mortality and worse functional outcome at discharge despite lower injury severity. *Journal of Trauma - Injury, Infection and Critical Care, 53*(2), 219-224.

Tagliaferri, F., Compagnone, C., Korsic, M., Servadei, F., & Kraus, J. (2006). A systematic review of brain injury epidemiology in Europe. *Acta Neurochirurgica, 148*(3), 255-268.

Tate, R. L., McDonald, S., & Lulham, J. M. (1998). Incidence of hospital-treated traumatic brain injury in an Australian community. *Australian and New Zealand Journal of Public Health, 22*(4), 419-423.

Teasdale, G. M., Murray, G., Anderson, E., Mendelow, A. D., MacMillan, R., Jennett, B., et al. (1990). Risk of acute traumatic intracranial haematoma in children and adults: Implications for managing head injuries. *British Medical Journal, 300*(6721), 363-367.

Tellier, A., Della Malva, L. C., Cwinn, A., Grahovac, S., Morrish, W., & Brennan-Barnes, M. (1999). Mild head injury: A misnomer. *Brain Injury, 13*(7), 463-475.

Thompson, H. J., McCormick, W. C., & Kagan, S. H. (2006). Traumatic brain injury in older adults: Epidemiology, outcomes, and future implications. *Journal of the American Geriatrics Society, 54*(10), 1590-1595.

Thornhill, S., Teasdale, G. M., Murray, G. D., McEwen, J., Roy, C. W., & Penny I, K. I. (2000). Disability in young people and adults one year after head injury: Prospective cohort study. *British Medical Journal, 320*(7250), 1631-1635.

Thurman, D., & Guerrero, J. (1999). Trends in hospitalization associated with traumatic brain injury. *Journal of the American Medical Association, 282*(10), 954-957.

Thurman, D. J., Alverson, C., Dunn, K. A., Guerrero, J., & Sniezek, J. E. (1999). Traumatic brain injury in the United States: A public health perspective. *Journal of Head Trauma Rehabilitation, 14*(6), 602-615.

Tomarken, A. J., & Serlin, R. C. (1986). Comparison of anova Alternatives Under Variance Heterogeneity and Specific Noncentrality Structures. *Psychological Bulletin, 99*(1), 90-99.

Tombaugh, T. N. (2004). Trail Making Test A and B: Normative data stratified by age and education. *Archives of Clinical Neuropsychology, 19*(2), 203-214.

Trevena, L., Cameron, I. G., & Porwal, M. (2004). *Clinical practice guidelines for the care of people living with traumatic brain injury in the community* Sydney The University of Sydney.

Turner-Stokes, L. (2002). Standardized outcome assessment in brain injury rehabilitation for younger adults. *Disability and Rehabilitation, 24*(7), 383-389.

Turner-Stokes, L. (2008). Evidence for the effectiveness of multi-disciplinary rehabilitation following acquired brain injury: A synthesis of two systematic approaches. *Journal of Rehabilitation Medicine, 40*(9), 691-701.

Turner-Stokes, L., Disler, P. B., Nair, A., & Wade, D. T. (2005). Multi-disciplinary rehabilitation for acquired brain injury in adults of working age. *Cochrane database of systematic reviews (Online)*(3).

Turner, B. J., Fleming, J., Ownsworth, T., & Cornwell, P. (2011). Perceived service and support needs during transition from hospital to home following acquired brain injury. *Disability and Rehabilitation, 33*(10), 818-829.

Vakil, E. (2005). The effect of moderate to severe traumatic brain injury (TBI) on different aspects of memory: A selective review. *Journal of Clinical and Experimental Neuropsychology, 27*(8), 977-1021.

van der Naalt, J., van Zomeren, A. H., Sluiter, W. J., & Minderhoud, J. M. (1999). One year outcome in mild to moderate head injury: the predictive value of acute injury characteristics related to complaints and return to work. *Journal of Neurology Neurosurgery and Psychiatry, 66*(2), 207-213.

Van Reekum, R., Bolago, I., Finlayson, M. A. J., Garner, S., & Links, P. S. (1996). Psychiatric disorders after traumatic brain injury. *Brain Injury, 10*(5), 319-327.

Van Reekum, R., Cohen, T., & Wong, J. (2000). Can traumatic brain injury cause psychiatric disorders? *Journal of Neuropsychiatry and Clinical Neurosciences, 12*(3), 316-327.

Vanderploeg, R. D., Curtiss, G., Duchnick, J. J., & Luis, C. A. (2003). Demographic, medical, and psychiatric factors in work and marital status after mild head injury. *Journal of Head Trauma Rehabilitation, 18*(2), 148-163.

Vanderploeg, R. D., Schinka, J. A., & Axelrod, B. N. (1996). Estimation of WAIS-R premorbid intelligence: Current ability and demographic data used in a best-performance fashion. *Psychological Assessment, 8*(4), 404-411.

Varney, N. R., Bushnell, D. L., Nathan, M., Kahn, D., Roberts, R., Rezai, K., et al. (1995). NeuroSPECT correlates of disabling mild head injury: Preliminary findings. *Journal of Head Trauma Rehabilitation, 10*(3), 18-28.

Varney, N. R., Martzke, J. S., & Roberts, R. J. (1987). Major depression in patients with closed head injury. *Neuropsychology, 1*(1), 7-9.

Vollmer, D. G., Torner, J. C., Jane, J. A., Sadovnic, B., Charlebois, D., Eisenberg, H. M., et al. (1991). Age and Outcome Following Traumatic Coma - Why Do Older Patients Fare Worse. *Journal of Neurosurgery, 75*, S37-S49.

von Holst, H., & Cassidy, J. D. (2004). Mandate of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. *Journal of Rehabilitation Medicine, Supplement*(43), 8-10.

Wade, D. T. (1997). Epidemiology of disabling neurological disease: How and why does disability occur? *Journal of Neurology Neurosurgery and Psychiatry, 63*(SUPPL. 1).

Wade, D. T., Crawford, S., Wenden, F. J., King, N. S., & Moss, N. E. G. (1997). Does routine follow up after head injury help? A randomised controlled trial. *Journal of Neurology Neurosurgery and Psychiatry, 62*(5), 478-484.

Wade, D. T., & De Jong, B. A. (2000). Recent advances in rehabilitation. *British Medical Journal, 320*(7246), 1385-1388.

Wade, D. T., King, N. S., Wenden, F. J., Crawford, S., & Caldwell, F. E. (1998). Routine follow up after head injury: a second randomised controlled trial. *Journal of Neurology Neurosurgery and Psychiatry, 65*(2), 177-183.

Wagner, A. K., Hammond, F. M., Sasser, H. C., Wiercisiewski, D., & Norton, H. J. (2000). Use of injury severity variables in determining disability and community integration after traumatic brain injury. *Journal of Trauma-Injury Infection and Critical Care, 49*(3), 411-419.

Webb, C. R., Wrigley, M., Yoels, W., & Fine, P. R. (1995). Explaining quality of life for persons with traumatic brain injuries 2 years after injury. *Archives of Physical Medicine and Rehabilitation, 76*(12), 1113-1119.

Wechsler, D. (1958). *The measurement and appraisal of adult intelligence* (4th ed.). Baltimore: Wilson & Wilkins

Wechsler, D. (1981). Wechsler Adult Intelligence Scale-Revised. San Antonio: Psychological Corporation

Wechsler, D. (1996). Wechsler Adult Intelligence Scale III. New York: Psychological Corporation

Weddell, R., Oddy, M., & Jenkins, D. (1980). Social adjustment after rehabilitation: a two year follow-up of patients with severe head injury. *Psychological Medicine, 10*(2), 257-263.

Wenden, F. J., Crawford, S., Wade, D. T., King, N. S., King, N. S., & Moss, N. E. G. (1998a). Assault, post-traumatic amnesia and other variables related to outcome following head injury. *Clinical Rehabilitation, 12*(1), 53-63.
Wenden, F. J., Crawford, S., Wade, D. T., King, N. S., & Moss, N. E. G. (1998b). Assault, post-traumatic amnesia and other variables related to outcome following head injury. *Clinical Rehabilitation, 12*(1), 53-63.
Wepman, J. M. (1951). *Recovery from aphasia* New York: Ronald Press
Whelan-Goodinson, R., Ponsford, J., & Schönberger, M. (2009). Validity of the Hospital Anxiety and Depression Scale to assess depression and anxiety following traumatic brain injury as compared with the Structured Clinical Interview for DSM-IV. *Journal of Affective Disorders, 114*(1-3), 94-102.
Whiteneck, G., Brooks, C. A., Mellick, D., Harrison-Felix, C., Terrill, M. S., & Noble, K. (2004a). Population-based estimates of outcomes after hospitalization for traumatic brain injury in Colorado. *Archives of Physical Medicine and Rehabilitation, 85*(4), S73-S81.
Whiteneck, G. G., Charlifue, S. W., Gerhart, K. A., Overholser, J. D., & Richardson, G. N. (1992). Quantifying handicap: A new measure of long-term rehabilitation outcomes. *Archives of Physical Medicine and Rehabilitation, 73*(6), 519-526.
Whiteneck, G. G., Gerhart, K. A., & Cusick, C. P. (2004b). Identifying environmental factors that influence the outcomes of people with traumatic brain injury. *Journal of Head Trauma Rehabilitation, 19*(3), 191-204.
Whitnall, L., McMillan, T. M., Murray, G. D., & Teasdale, G. M. (2006). Disability in young people and adults after head injury: 5-7 Year follow up of a prospective cohort study. *Journal of Neurology, Neurosurgery and Psychiatry, 77*(5), 640-645.
Wickett, J. C., Vernon, P. A., & Lee, D. H. (2000). Relationships between factors of intelligence and brain volume. *Personality and Individual Differences, 29*(6), 1095-1122.
Willer, B., Rosenthal, M., Kreutzer, J. S., Gordon, W. A., & et al. (1993). Assessment of community integration following rehabilitation for traumatic brain injury. *Journal of Head Trauma Rehabilitation, 8*(2), 75-87.
Wilson, J. T. L., Teasdale, G. M., Hadley, D. M., Wiedmann, K. D., & Lang, D. (1994). Posttraumatic Amnesia - Still a Valuable Yardstick. *Journal of Neurology Neurosurgery and Psychiatry, 57*(2), 198-201.
Wood, R. L. (2004). Understanding the 'miserable minority': A diasthesis-stress paradigm for post-concussional syndrome. *Brain Injury, 18*(11), 1135-1153.
Wood, R. L., McCrea, J. D., Wood, L. M., & Merriman, R. N. (1999). Clinical and cost effectiveness of post-acute neurobehavioural rehabilitation. *Brain Injury, 13*(2), 69-88.
World Health Organisation. (2001). *International classification of functioning, disability, and health*. Geneva.
World Health Organization. (1990). International Classification of Diseases (Tenth ed.). Geneva: World Health Organisation.
Yates, P. J., Williams, W. H., Harris, A., Round, A., & Jenkins, R. (2006). An epidemiological study of head injuries in a UK population attending an emergency department. *Journal of Neurology, Neurosurgery and Psychiatry, 77*(5), 699-701.
Ylvisaker, M., Jacobs, H. E., & Feeney, T. (2003). Positive supports for people who experience behavioral and cognitive disability after brain injury: A review. *Journal of Head Trauma Rehabilitation, 18*(1), 7-32.

Zasler, N. D. (1997). Prognostic indicators in medical rehabilitation of traumatic brain injury: A commentary and review. *Archives of Physical Medicine and Rehabilitation*, *78*(8), S12-S16.

Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta Psychiatrica Scandinavica*, *67*(6), 361-370.

APPENDICIES

Tasmania
DEPARTMENT *of* HEALTH *and* HUMAN SERVICES

Human Research Ethics Committee (Tasmania) Network

UNIVERSITY OF TASMANIA

Southern Tasmania Health and Medical Human Research Ethics Committee APPLICATION APPROVAL

To:	Dr Mark Slatyer Rehabilitation Unit Royal Hobart Hospital
From:	Amanda McAully Executive Officer
Date:	13th May 2003
Subject:	H7116 Establishment of a traumatic brain injury register for Tasmania

The Southern Tasmania Health and Medical Human Research Ethics Committee on **8th May 2003** recommended approval of this project.

You are required to report immediately anything which might affect ethical acceptance of the project, including:

- serious or unexpected adverse effects on participants;
- proposed changes in the protocol;
- unforeseen events that might affect continued ethical acceptability of the project.

You are also required to inform the Committee if the project is discontinued before the expected date of completion, giving the reasons for discontinuation.

Please Note:
Approval is subject to annual review. You will be asked to submit your first report on this project by **8th May 2004.**

Contact: University of Tasmania
Research and Development Office
GPO Box 252-01
Hobart Tas 7001
Phone: 62 262763
Fax: 62267148
Email: Amanda.McAully@utas.edu.au

The Southern Tasmania Human Research Ethics Committee is constituted under the NHMRC Guidelines and continues to meet the compliance regulations. The Committee is required to report to the NRMRC annually. The composition of the committee includes the 6 categories as per 2.6 of the National Statement on Ethical Conduct and also includes extra expertise.

Yours Sincerely

Amanda McAully

Contact: University of Tasmania
Research and Development Office
GPO Box 252-01
Hobart Tas 7001
Phone: 62 262763
Fax: 62267148
Email: Amanda.McAully@utas.edu.au

Private Bag 01 Hobart
Tasmania 7001 Australia
Telephone (03) 6226 2763
Facsimile (03) 6226 7148
Timothy.Sculthorpe@utas.edu.au
http://www.research.utas.edu.au/

MEMORANDUM

UTAS

HUMAN RESEARCH ETHICS COMMITTEE (TASMANIAN) NETWORK

16 October 2006

Mr Mark Slatyer
Dwyer Ward
Royal Hobart Hospital
PO Box 1061
Hobart 7000

Dear Mr Slatyer

REF NO: **H0007116**
TITLE: **Neurotrauma Register and brain injury research**

Dated 12 July 06. To collect information on the care and support needs of TBI patients

The Human Research Ethics Committee (Tasmania) Network considered and approved the above documentation at its meeting on 09 October 2006.

All committees operating under the Human Research Ethics Committee (Tasmania) Network are registered and required to comply with the *National Statement on the Ethical Conduct in Research Involving Humans 1999* (NHMRC guidelines).

Should you have any queries please do not hesitate to contact me on (03) 6226 2763 in the first instance.

Yours sincerely

Tim Sculthorpe
Ethics Officer, Health and Medical
On behalf of the Executive Officer
HREC (TAS) Network

A PARTNERSHIP PROGRAM IN CONJUNCTION WITH THE DEPARTMENT OF HEALTH AND HUMAN SERVICES

Office of Research Services
University of Tasmania
Private Bag 1
Hobart Tasmania 7001
Telephone + 61 3 6226 7479
Facsimile + 61 3 6226 7148
Email Human.Ethics@utas.edu.au
www.research.utas.edu.au/human_ethics/

HUMAN
RESEARCH
ETHICS
COMMITTEE
(TASMANIA)
NETWORK

UTAS

28 September 2007

Dr MA Slatyer
Rehabilitation Physician
GPO Box 482
Hobart TAS 7001

Dear Dr Slatyer

REF NO: **H0007116**
TITLE: **Neurotrauma Register and brain injury research**

Removal of additional verbal consent being collected before data collection is started at the Community Rehabilitation Unit

The Tasmanian Health and Medical Human Research Ethics Committee considered and approved the above documentation at its meeting on 24 September 2007.

All committees operating under the Human Research Ethics Committee (Tasmania) Network are registered and required to comply with the *National Statement on Ethical Conduct in Human Research* (NHMRC 2007).

Should you have any queries please do not hesitate to contact me on (03) 6226 2763.

Yours sincerely

Katherine Shaw
Ethics Officer, Health and Medical
On behalf of the Executive Officer
HREC (TAS) Network

Tasmania
Explore the possibilities

A PARTNERSHIP PROGRAM BETWEEN THE DEPARTMENT OF HEALTH AND HUMAN SERVICES AND THE UNIVERSITY OF TASMANIA

UNIVERSITY OF TASMANIA

Neurotrauma Research Group
Centre for Clinical Research
Level 2, 24 Campbell Street
Private Bag 34
Hobart Tasmania 7001 Australia
Telephone: 61-3-6226-4705
Fax: 61-3-6226-4704

INFORMATION SHEET

Establishment of a Neurotrauma Register for Tasmania.

Chief Investigator: Dr Mark Slatyer

Introduction
You have been asked to participate in the Tasmanian Neurotrauma Register, because you have had a head injury. The study will be conducted for 1 year initially. Funding for a permanently established neurotrauma database may be possible depending on the results of the study.

Purpose of the study
Head injuries are common in Tasmania, but we do not know how well people recover. We need to find everyone who has a head injury and then assess their recovery over time.

Study procedures
If you agree to take part in the study you will be given some memory tests to assess your ability to think (memory) within 1 week of your head injury, and some questionnaires about your life and how you feel. Each time, the assessment will take between 30 and 90 minutes approximately. Other data about your head injury and treatment and background information (e.g. age and occupation) will also be collected.

Possible risks or discomforts
The study has no anticipated risks for you. If you find the tests tiring, rest breaks will be provided at any time.

Confidentiality
The confidentiality of your research data will be ensured via a password-protected computer database. Only the researchers and their support staff will have access to the database and to paper research records. All paper research records will be kept in locked filing cabinets in the research office at the Royal Hobart Hospital for at least 5 years and will be destroyed when no longer needed. The computer database will continue to be maintained under confidential, password-protected

Freedom to refuse or withdraw
Your participation in this study is entirely voluntary and you can withdraw at any time without any prejudice to your future care.

Concerns or complaints
This study has ethical approval from the Southern Tasmania Health & Medical Human Research Ethics Committee. If you have any concerns of an ethical nature or complaints about the manner in which the study is conducted you may contact the Chair or Executive of the Ethics Committee:

Chair:	Dr Helen McArdle	6222 8430
Executive Officer:	Mrs Amanda McAully	6226 2763

Payment to subjects
There is no payment made for joining the study.

Information sheet and consent form
You will be given copies of this information sheet and the consent form to keep.

Contact persons
Should you need more information, you can contact:

Principle Investigator	Dr Mark Slatyer	6234 7555

UNIVERSITY
OF TASMANIA

Neurotrauma Research Group
Centre for Clinical Research
Level 2, 24 Campbell Street
Private Bag 34
Hobart Tasmania 7001 Australia
Telephone: 61-3-6226-4705
Fax: 61-3-6226-4704

CONSENT FORM

Establishment of a Neuro-trauma Register for Tasmania.

1. I have read and understood the 'Information Sheet' for this study.
2. The nature and possible effects of the study have been explained to me.
3. I understand that the study involves intellectual and memory tests, questionnaires and the collection of clinical and background personal information.
4. I understand that some tests may be tiring and that I can take rest breaks.
5. I have been informed that the results of the study may not be of any direct benefit to my medical management.
6. Any questions that I have asked have been answered to my satisfaction.
7. I agree that research data gathered for the study may be published provided that I cannot be identified as a participant.
8. I consent to having my name checked against the Hospital Medical Records of my head injury.
9. I agree to participate in this study and understand that I may withdraw at any time without prejudice to my future care.
10. I consent to having data on my head/spinal injury checked with my general practitioner and treating specialist.
11. I consent to having my name checked against other similar registers (eg. State Injury Register, Epilepsy Register).

You may choose to opt out of points 10 or 11 by crossing them out. Please date and initial.

Name of **participant** ....

Signature:..Date:............

Name of **witness** ....

Signature:..Date:............

For people under 18 years of age or who are unable to give informed consent a written consent from the parent or legal guardian is required:

Name of parent/guardian:...

Signature of parent/guardian:..............................Date:..................

I have explained this study and the implications of participation in it to this volunteer/parent/guardian and I believe that the consent is informed and that he/she understands the implications of participation.

Name of researcher:..

Signature of researcher:..

Date:..

Version 4; 10 November 2003

Rivermead Symptom Checklist

Name ______________________________

We would like to know whether you are currently experiencing any of the following symptoms we list below. Because many of these symptoms occur normally, we would like you to compare yourself as you are now with how you were before the accident.

For each of the following will you please circle the number closest to your answer.

0 = Not experienced at all
1 = Was a problem but no more
2 = A mild problem
3 = A moderate problem
4 = A severe problem

Compared with before the accident, do you now suffer from:

	Assessment .... **Date**					**Assessment** .... **Date**					**Assessment** .... **Date**				
1. Headaches	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
2. Feeling of dizziness	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
3. Nausea and/or vomiting	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
4. Sensitivity to noise	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
5. Poor sleep	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
6. Tiring more easily, fatigue	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
7. Being irritable, easily angered	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
8. Feeling depressed or tearful	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
9. Feeling frustrated and impatient	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
10. Forgetful, poor memory	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
11. Poor concentration	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
12. Taking longer to think	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
13. Blurred vision	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
14. Upset to bright light	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
15. Double vision	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
16. Restlessless	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4

The following have been removed for copyright or proprietary reasons

Appendix D - Example Hospital Anxiety and Depression Scale response sheet

Appendix E - Example National Adult Reading Test response sheet

Appendix F Example Functional Independence Measure response sheet

Functional Independence Measure (FIM)

Self Care
A. Eating
B. Grooming
C. Bathing
D. Dressing- Upper
E. Dressing- Lower
F. Toileting

Sphincter Control
G. Bladder
H. Bowel

Transfers
I. Bed, Chair, Wheelchair
J. Toilet
K. Tub, Shower

Locomotion
L. Walk/Weelchair
M. Stairs

Communication
N. Comprehension
O. Expression

Social Cognition
P. Social Interaction
Q. Problem Solving
R. Memory

FIM Levels

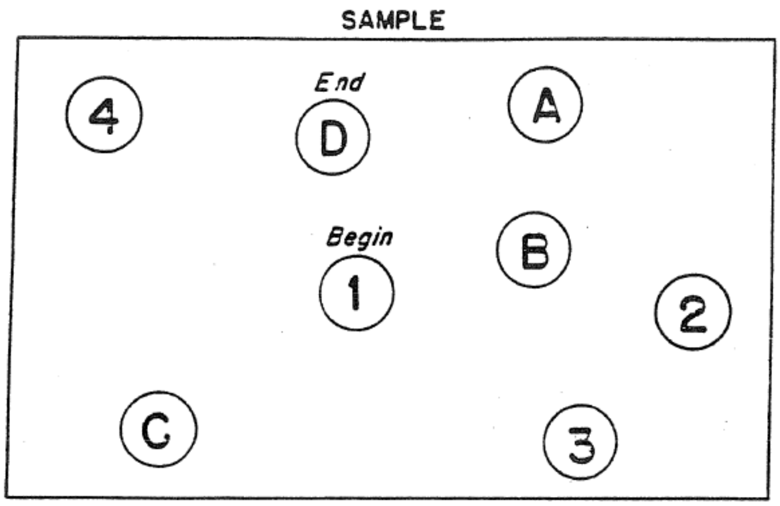
No helper	- 7 – Complete Independence (Timely, Safely).
	- 6 – Modified Independence
Helper – Modified Independence	- 5 – Supervision (Subject=100%)
	- 4 – Minimal Assistance (Subject=75%)
	- 3 – Moderate Assistance (Subject=50%)
Helper – Complete Dependence	- 2 – Maximal Assistance (Subject= 25%)
	- 1- Total Assistance or not testable (Subject< 25%)

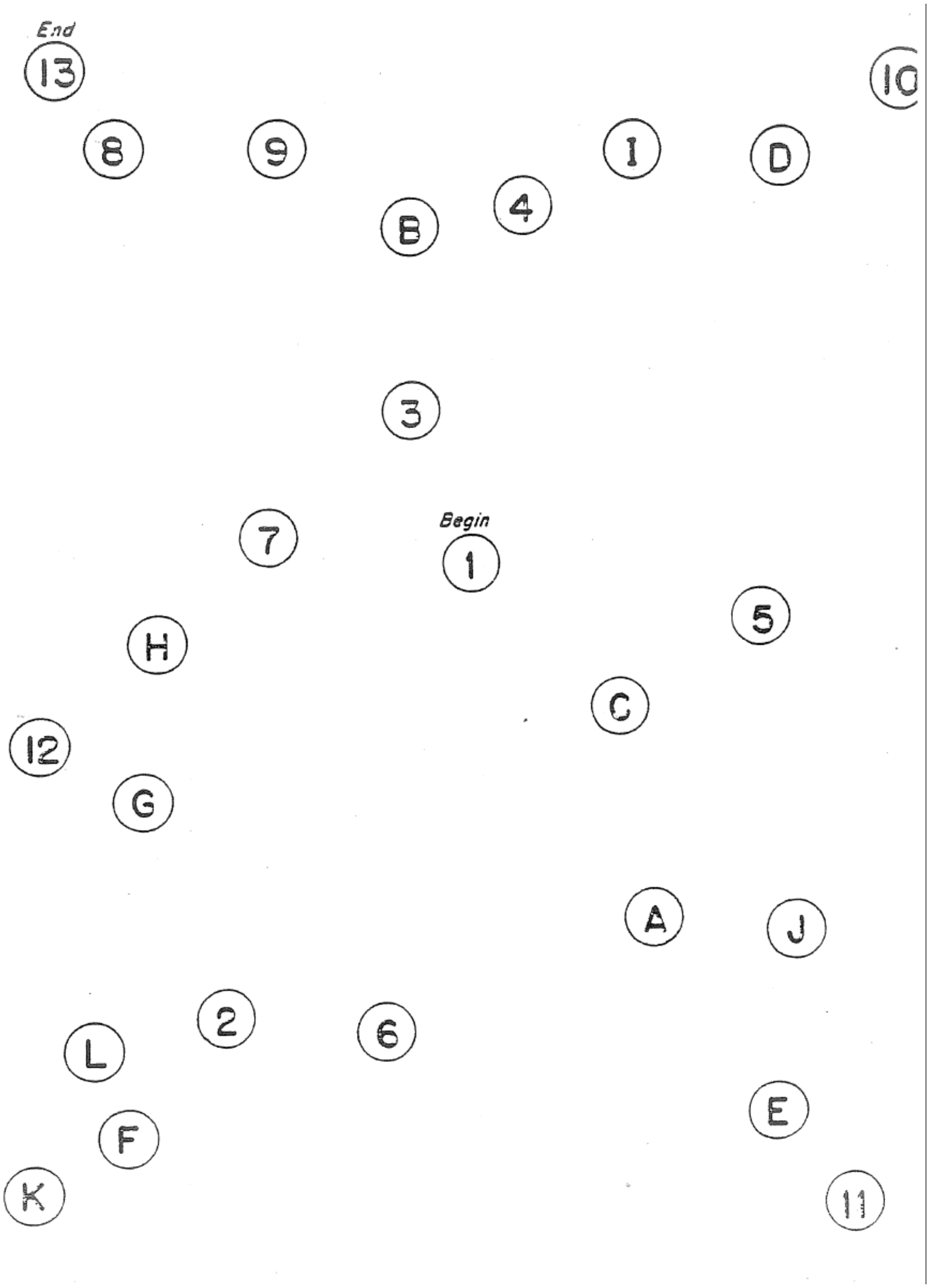
The following have been removed for copyright or proprietary reasons

Appendix G- Disability Rating Scale

TRAIL MAKING

Part B




End
13
10
8
9
I
D
4
B
3
Begin
7
1
5
H
C
12
G
A
J
2
6
L
E
F
K
11

8. Digit Span

DISCONTINUE RULE
Digits Forward & Backward:
Score of 0 on both trials of any item.
For both Digits Forward & Backward, administer both trials of each item even if Trial 1 is passed. Administer Digits Backward even if examinee scores 0 on Digits Forward.

SCORING RULE
Each Trial: 0 or 1 pt. for each response
Item score = Trial 1 + Trial 2

START

Digits Forward Item	Trial	Item/Response	Trial Score	Item Score (0, 1 or 2)
1.	1	1-7		
	2	6-3		
2.	1	5-8-2		
	2	6-9-4		
3.	1	6-4-3-9		
	2	7-2-8-6		
4.	1	4-2-7-3-1		
	2	7-5-8-3-6		
5.	1	6-1-9-4-7-3		
	2	3-9-2-4-8-7		
6.	1	5-9-1-7-4-2-8		
	2	4-1-7-9-3-8-6		
7.	1	5-8-1-9-2-6-4-7		
	2	3-8-2-9-5-1-7-4		
8.	1	2-7-5-8-6-2-5-8-4		
	2	7-1-3-9-4-2-5-6-8		

Digits Forward Total Score (Maximum = 16)

Digits Backward Item	Trial	Item/Response	Trial Score	Item Score (0, 1 or 2)
1.	1	2-4		
	2	5-7		
2.	1	6-2-9		
	2	4-1-5		
3.	1	3-2-7-9		
	2	4-9-6-8		
4.	1	1-5-2-8-6		
	2	6-1-8-4-3		
5.	1	5-3-9-4-1-8		
	2	7-2-4-8-5-6		
6.	1	8-1-2-9-3-6-5		
	2	4-7-3-9-1-2-8		
7.	1	9-4-3-7-6-2-5-8		
	2	7-2-8-1-9-6-5-3		

Digits Backward Total Score (Maximum = 14)

Forward + Backward = (Maximum = 30)

The following have been removed for copyright or proprietary reasons

Appendix J- Information Processing Task

Appendix K

Comparison of Mean Anxiety and Depression Scores for Study 1 Groups

	Anxiety (HADS)			Depression (HADS)					
	n	*M*	*SD*	*n*	*M*	*SD*	*t*	*df*	*p*
Whole Sample	1123	7.86	4.97	1123	5.32	4.37	22.88	1122	<.001
CRU-TNTR	110	12.22	5.25	110	8.82	4,91	8.84	109	<.001
CRU-Other	49	6.31	4.91	49	5.67	3.88	1.11	48	.27
Private	227	7.49	4.80	227	5.27	4.40	8.80	226	<.001
No-Rehab	737	7.42	4.65	737	4.79	4.06	19.87	736	<.001

Appendix L

Distribution of Cognitive Test Scores for Study 1 sample

Digit Span (*n* = 902)		Information Processing (*n* = 809)	
Mean	9.09 (*SD* = 2.76)	Mean	39.77 (*SD* = 29.49)
Median	9.00	Median	32.00
< 8 Below-average	266 (30%)	<25 Below-average	310 (38%)
8-12 Average	541 (60%)	25-75 Average	365 (45%)
> 12 Above-average	95 (11%)	>75 Above-average	134 (17%)
Trails B (*n* = 831)		**COWAT (*n* = 877)**	
Mean	23.62 (*SD* = 27.49)	Mean	24.71 (*SD* = 25.17)
Median	10.00	Median	15.00
<25 Below-average	514 (62%)	< 8 Below-average	534 (61%)
25-75 Average	255 (31%)	8-12 Average	298 (34%)
>75 Above-average	62 (7%)	> 12 Above-average	45 (5%)

Appendix M

Comparison of Study 1 Hospitalised Participants by Cause of Injury

Percent Hospitalised (n = 508)		χ^2 (3) = 100.50	p <.001	Post-hoc Comparisons
Transport	71%			v 2; χ^2 (1) = 164.86, p <.001 v 3; χ^2 (1) = 34.84, p <.001
Assaults	23%			v 1; χ^2 (1) = 164.86, p <.001 v 3; χ^2 (1) = 37.73, p <.001
Falls	48%			v 1; χ^2 (1) = 34.84, p <.001 v 2; χ^2 (1) = 37.73, p <.001

Appendix N

Comparison of Mean PTA by Cause of Injury for Study 1 Participants

Referral Source (*n*)	*M*	*SD*	*F* = 10.63	*p* <.001	Post-hoc Comparisons
Transport (457)	4.84	13.04			v 2; *p* <.001 v 3; *p* =.006
Assaults (322)	1.68	5.39			v 1; *p* <.001
Falls (253)	2.45	7.78			v 1; *p* =.006

Appendix O

Comparison of Hospitalised No-Rehab Participants by Injury-severity

	Hospitalised	Not-hospitalised	Missing Data (Hospitalisation)	Total
≤ 24 hours PTA (Mild)	208	384	49	641 (80%)
> 1 day PTA (Mod/Severe)	74	41	9	124 (16%)
Missing Data (PTA)				39 (5%)
Total				804 (100%)

The following have been removed for copyright or proprietary reasons

Appendix P- Discharge Sheet

Appendix Q

Effect of Age on Service Utilisation in Study 2

Age Bands	Referred to > 2 disciplines	Percent
16-30 years (*n* = 66)	25	38%
31-40 years (*n* = 47)	25	53.%
41-59 years (*n* = 45)	24	53%
> 59 years (*n* = 17)	9	53%

	Referral to > 2 disciplines	*n*	χ^2	*df*	*p*
Age (*n* = 175)					
16-30 years	38%	25	3.88	1	.049
>30 years	53%	58			
Age (*n* = 175)					
16-40 years	44%	50	1.29	1	.26
>40 years	53%	33			
Age (*n* = 175)					
16-50 years	48%	68	0.64	1	.80
>50 years	46%	15			
Age (*n* = 175)					
16-59 years	47%	74	0.23	1	.63
>59 years	53%	9			

Appendix R

Comparison of Study 2 Sample's Mean Estimated Premorbid IQ by Age

Age Bands (*n*)	*M*	*SD*	*F* = 5.51	*p* =.001	Post-hoc Comparisons
16-30 years (44)	92.39	12.73			v 3; *p* <.003 v 4; *p* =.028
31-40 years (33)	95.30	12.37			n.s.
41-59 years (29)	102.14	9.07			v 1; *p* <.003
<59 years (13)	102.77	10.99			v 1; *p* =.028

Appendix S

Comparison of years of education by age for Study 2 Participants

Age Bands (*n*)	*M*	*SD*	*F* = 1.49	*p* <.22	Post-hoc Comparisons
16-30 years (66)	11.18	2.08			n.s.
31-40 years (46)	10.26	1.32			n.s.
41-59 years (45)	10.62	2.34			n.s.
<59 years (16)	11.08	4.90			n.s.

Age (*n* = 173)	≤ 10 years education	*n*	χ^2	*df*	*p*
16-30 years	47%	31	7.69	1	.006
<30 years	68%	73			

Appendix T

Comparison of Cause of Injury in Psychology and Occupational Therapy Referrals

Referrals to Psychology by cause of injury (*n* = 127)

Percentage referred to Psychology		χ^2 (3) = 8.79	*p* =.012	Post-hoc Comparisons
Assaults	87%			v 2; χ^2 (1) = 8.33, p <.004
Transport	65%			v 1; χ^2 (1) = 8.33, p <.004
Falls	81%			n.s.

Referrals to Occupational Therapy by cause of injury (*n* = 44)

Percentage referred to Occupational Therapy		χ^2 (3) = 6.18	*p* =.045	Post-hoc Comparisons
Assault	19%			v 3; χ^2 (1) = 6.20, p <.013
Transport	28%			n.s.
Falls	41%			v 1; χ^2 (1) = 6.20, p <.013

Appendix U

Percentage of Mild Injuries in Previous TBI Groups

Percent mild injury (≤1 day PTA)	$\chi^2 = 0.92$ (1)	*p* =.76
No previous TBI	80%	
Previous TBI	81%	

No previous TBI			Previous TBI					
n	*M*	*SD*	*n*	*M*	*SD*	*t*	*df*	*p*
140	5,72	11.35	35	4.80	9.87	0.44	173	.66

The following have been removed for copyright or proprietary reasons

Appendix V- Referral Form for Community Rehabilitation Unit

Appendix W

Neuopsychological assessments by referral source

Percent Psychology referrals given a neuropsychological assessment		$\chi^2 = 8.46$ (1)	p =.004
CRU-TNTR (24)	24%		
CRU-Other (19)	50%		

Appendix X

Comparison of Therapy and No-therapy Groups for Study Variables

	Therapy	No therapy	χ^2	*df*	*p*
Percent male *n* = 119	66%	80 %	1.93	1	.17
Percent previous TBI *n* = 35	22%	12%	1.17	1	.28
Percent hospitalised *n* = 93	55%	40%	2.02	1	.16
Percent Assaults *n* = 69	37%	52%	1.93	1	.17
Percent Transport	29%	28%	0.02	1	.89
Percent Falls *n* = 42	25%	16%	1.02	1	.31
Percent Southern Tas. *n* = 163 [a]	95%	88%		1	.38

Note. [a] Fishers Exact test was used, in accordance with (McPherson, 1990), because at least one cell has expected frequency of < 3

	Therapy			No therapy					
	n	*M*	*SD*	*n*	*M*	*SD*	*t*	*df*	*p*
Age-at-injury	175	37.74	15.08	25	32.58	14.88	1.59	173	.12
Education	149	10.68	2.30	24	11.42	2.89	1.38	118	.17
Premorbid IQ	106	97.22	12.22	15	92.53	12.59	1.38	119	.17
Severity (PTA)	150	5.57	11.10	25	5.35	10.96	0.09	173	.93
FIM	143	118.56	16.06	23	120.74	11.28	0.63	164	.52
RPQ	146	28.69	15.13				0.57	168	.57
Anxiety (HADS)	136	10.46	5.72	23	10.00	8.51	0.35	157	.73
Depression (HADS)	136	8.02	4.92	23	6.83	4.23	1.10	157	.27

Appendix Y

Impact of Study Variables on Total Therapy (TT) Across Disciplines

	n	*M*	*SD*	*t*	*F*	*df*	*p*
Gender				1.46		65	.15
Female	51	9.37	15.14				
Male	99	6.04	7.95				
Age							
16-30 years	48	3.74*	4.20		4.59	3	**.006**
31-40 years	45	6.45	13.85				
41-59 years	41	11.80*	16.82				
> 59 years	16	7.66	7.22				
Education							
<10 years	24	7.94	9.86		1.08	3	.36
10 years	68	6.38	9.15				
11 years	24	5.19	6.35				
> 12 years	33	9.88	16.60				
IQ (NART/WAIS Vocab.)							
< 90 IQ	29	5.25	6.80		2.83	2	.07
90-109	59	7.68	9.89				
> 109	18	16.83	21.87				
Previous TBI				1.44		148	.15
No previous TBI	118	6.50	10.65				
Previous TBI	32	9.66	12.07				
Cause of Injury					0.66	.2	.52
Assaults	56	6.45	7.86				
Transport	44	7.27	14.90				
Falls	38	9.20	11.16				
Hospitalisation				0.05		148	.96
Not Hospitalised	67	7.23	10.60				
Hospitalised	83	7.13	11.38				
Post Traumatic Amnesia							
≤ 1 hour	37	5.49	7.32		0.75	3	.53

>1 hour-24 hours	38	7.19	11.11				
> 1 day-7 days	49	7.10	9.82				
> 7 days	26	9.71	16.29				
PCS (RPQ)				0.58		141	.57
Minimal to Mild	50	6.53	12.09				
Moderate to Severe	93	7.67	10.79				
Anxiety (HADS)					0.47	3	.70
Normal	43	7.38	13.07				
Mild	20	5.64	6.74				
Moderate	34	6.71	10.44				
Severe	40	9.05	12.32				
Depression (HADS)					0.85	3	.47
Normal	69	6.87	11.76				
Mild	26	6.83	8.34				
Mod	26	6.10	8.62				
Severe	15	13.73	17.00				
FIM				1.50		142	.14
Not-independent	93	8.35	10.78				
Independent	51	5.44	11.75				

Note. An asterix indicates significantly different groups in post-hoc comparisons

Appendix Z

Impact of Study Variables on Total Therapy (TT) in Separate Disciplines

Relationship between study variables and TT in Nursing

	n	*M*	*SD*	*t*	*F*	*df*	*p*
Gender				1.16		106	.25
Female	39	1.16	0.67				
Male	69	0.99	0.76				
Age					`.32	3	.27
16-30 years	37	1.06	0.64				
31-40 years	34	1.12	0.78				
41-59 years	29	1.09	0.62				
> 59 years	8	0.56	0.99				
Education					0.92	3	.44
<10 years	19	1.06	0.81				
10 years	46	1.17	0.79				
11 years	17	0.98	0.75				
> 11 years	25	0.87	0.53				
IQ (NART/WAIS Vocab.)					0.70	2	.50
< 90 IQ	20	1.09	0.68				
90-109	45	1.06	0.77				
> 109	11	1.38	1.08				
Previous TBI				2.02		106	.045
No previous TBI	84	0.97	0.74				
Previous TBI	24	1.31	0.64				
Cause of Injury				.95		2	.39
Assaults	41	1.17	0.80				
Transport	29	0.93	0.56				
Falls	29	1.09	0.79				
Hospitalisation				1.38		106	.59
Not Hospitalised	53	1.15	0.78				
Hospitalised	55	0.95	0.68				
Post Traumatic Amnesia					0.18	3	.91
≤ 1 hour	27	1.03	0.90				

>1 hour-24 hours	30	1.12	0.78				
> 1 day-7 days	35	1.00	0.66				
> 7 days	16	1.02	0.48				
PCS (RPQ)				0.57		103	.57
Minimal to Mild	42	0.99	0.68				
Moderate to Severe	63	1.08	0.77				
Anxiety (HADS)				1.89		95	.06
Normal to mild	44	0.92	0.56				
Moderate to Severe	53	1.19	0.82				
Depression (HADS)				3.30		92	**.001**
Normal to mild	63	0.90	0.52				
Moderate to severe	31	1.41	0.73				
FIM				2.06		102	.042
Not-independent	66	1.16	0.79				
Independent	37	0.85	0.60				

Relationship between study variables and TT in Psychology

	n	*M*	*SD*	*t*	*F*	*df*	*p*
Gender				0.02		93	.98
Female	31	5.24	6.59				
Male	64	5.20	6.17				
Age					2.36	3	.08
16-30 years	33	3.39	3.11				
31-40 years	25	5.39	7.01				
41-59 years	31	7.34	8.01				
> 59 years	6	3.53	1.83				
Education					0.41	3	.74
<10 years	15	5.83	8.28				
10 years	40	5.47	6.51				
11 years	19	3.79	2.74				
>11 years	21	5.57	6.70				

IQ (NART/WAIS Vocab.)					1.98	3	.16
< 90	20	3.65	4.79				
90-109	38	5.96	6.27				
> 109	12	8.88	10.63				
Previous TBI				0.65		93	.51
No previous TBI	70	4.96	6.07				
Previous TBI	25	5.92	6.87				
Cause of Injury					0.56	2	.58
Assaults	21	8.45	12.07				
Transport	41	8.33	8.42				
Falls	27	10.93	11.99				
Hospitalisation				0.82		77	.42
Not Hospitalised	45	5.78	7.39				
Hospitalised	50	4.70	5.09				
Post Traumatic Amnesia					0.39	3	.76
≤ 1 hour	19	3.91					
>1 hour-24 hours	29	8.11					
> 1 day-7 days	31	6.81					
> 7 days	16	3.05					
PCS (RPQ)				3.72		70	**.002**
Minimal/mild	32	3.16	1.60				
Mod/severe	61	6.43	7.48				
Anxiety (HADS)				1.92		67	.059
Normal to mild	37	4.02	2.93				
Moderate to severe	51	6.36	7.99				
Depression (HADS)				2.74		26	.011
Normal to mild	61	3.77	2.86				
Moderate to severe	25	9.48	10.27				
FIM				2.91		81	**.005**
Not-independent	63	6.19	7.37				
Independent	30	3.25	2.17				

Relationship between study variables and TT in Physiotherapy

	n	*M*	*SD*	*t*	*F*	*df*	*p*
Gender				2.01		14	.06
Female	15	13.14	18.28				
Male	30	3.54	4.28				
Age				1.06		43	.30
16- 30 years	8	2.75	2.25				
> 30 years	37	7.60	12.85				
Education				1.08		13	.12
≤11 years	32	5.01	6.21				
> 11 years	13	11.00	19.59				
IQ (NART/WAIS Vocab.)				0.43		35	.67
< =100	13	6.42	7.91				
> 100	24	8.34	14.86				
Previous TBI				0.31		43	.76
No previous TBI	33	7.08	13.01				
Previous TBI	12	5.82	7.78				
Cause of Injury				0.83		2	.44
Assaults	13	4.65	7.49				
Transport	13	10.60	19.63				
Falls	15	5.94	6.19				
Hospitalisation				0.46		43	.65
Not Hospitalised	15	5.58	7.18				
Hospitalised	30	7.32	13.62				
Post Traumatic Amnesia				0.69		43	.50
≤ 1 day	17	5.18	5.16				
>1 day	28	7.69	14.45				
PCS (RPQ)				1.20		16	.25
Minimal/mild	15	10.73	18.47				
Mod/severe	28	4.83	6.05				
Anxiety (HADS)							
Normal to mild	19	9.37	16.59	0.84		37	.41
Moderate to severe	20	5.99	6.62				

Depression (HADS)				1.05		35	.30
Normal	25	9.53	14.99				
Mild	12	4.86	4.53				
FIM				0.54		41	.59
Not-independent	30	6.16	6.81				
Independent	13	8.35	19.87				

Relationship between study variables and TT in Occupational Therapy

	n	*M*	*SD*	*t*	*F*	*df*	*p*
Gender				2.23		27	.83
Female	10	2.65	2.01				
Male	19	2.46	2.33				
Age				0.30		6	.77
16- 30 years	6	2.89	3.63				
> 30 years	23	2.43	1.75				
Education				0.13		27	.90
≤11 years	21	2.55	2.29				
> 11 years	8	2.44	2.03				
IQ (NART/WAIS Vocab.)				0.95		20	.35
< =100	13	3.09	2.68				
> 100	9	2.09	1.95				
Previous TBI				0.62		27	.54
No previous TBI	22	2.38	1.82				
Previous TBI	7	2.98	3.24				
Cause of Injury				0.04		2	.96
Assaults	10	2.42	2.87				
Transport	6	2.22	1.75				
Falls	12	2.56	1.86				
Hospitalisation							
Not Hospitalised		3.71	3.10	1.71		27	.09
Hospitalised		2.14	1.74				

Post Traumatic Amnesia				1.00		27	.33
≤ 1 day	9	3.13	2.93				
>1 day	20	2.25	1.79				
PCS (RPQ)				1.08		26	.29
Minimal/mild	14	2.04	1.68				
Mod/severe	14	2.94	2.64				
Anxiety (HADS)				0.23		22	.82
Normal to mild	16	2.51	2.54				
Moderate to severe	8	2.75	1.94				
Depression (HADS)				0.26		22	.80
Normal	20	2.53	2.44				
Mild	4	2.88	1.93				
FIM				0.97		6	.37
Not-independent	23	2.22	1.63				
Independent	6	3.69	3.62				

Relationship between study variables and TT in Social Work

	n	*M*	*SD*	*t*	*F*	*df*	*p*
Gender				0.51		24	.61
Female	9	2.78	3.86				
Male	17	2.14	2.50				
Age				0.32		24	.75
16- 30 years	3	1.83	1.04				
> 30 years	23	1.43	3.15				
Education				0.39		24	.70
≤11 years	20	2.23	3.26				
> 11 years	6	2.78	1.94				
IQ (NART/WAIS Vocab.)				1.43		9	.18
< =100	8	1.77	1.43				
> 100	8	4.07	4.47				
Previous TBI				0.56		24	.92

No previous TBI	17	2.12	2.87			
Previous TBI	9	2.81	3.31			
Cause of Injury						
Assaults	11	2.87	0.86	0.19	2	.83
Transport	5	2.23	2.69			
Falls	9	2.93	3.62			
Hospitalisation				0.99	24	.33
Not Hospitalised	15	2.86	3.70			
Hospitalised	11	1.68	1.47			
Post Traumatic Amnesia						
≤ 1 day	15	2.41	3.66	0.10	24	.92
>1 day	11	2.29	1.83			
PCS (RPQ)				0.35	23	.73
Minimal/mild	5	1.97	1.41			
Mod/severe	20	2.51	3.33			
Anxiety (HADS)				1.06	20	.30
Normal to mild	8	1.67	1.40			
Moderate to severe	14	3.14	3.77			
Depression (HADS)				0.91	19	.37
Normal	9	1.89	1.62			
Mild	12	3.19	4.04			
FIM				0.62	23	.54
Not-independent	18	2.67	3.45			
Independent	7	1.83	1.36			

Appendix AA

Comparison of Older Age Groups by Employment Status for Study 5

Percent in payed employment (*n* = 150)		$\chi^2\,(1) = 3.10$	*p* <.38	Post-hoc Comparisons
16-30 years (28)	53%			n.s.
31-40 years (16)	40%			n.s.
41-59 years (20)	49%			n.s.
> 59 years (5)	31%			n.s.